The Blast Furnace and Steel Plant

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The Blast Furnace and Steel Plant

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The Sage Foundation Reports

FOLLOWING the famous strike of 1913, the Colorado Fuel & Iron Company put into effect the Rockefeller Plan of Employees' Representation. The plan resulted from an intimate study of local conditions by W. L. Mackenzie King, now Premier of Canada, and was formulated by him. The details of the plan are too well known to discuss.

Apparently the enthusiastic hopes which accompanied its inception have not been realized. Apparently something is missing. Just what that missing something is, the Sage Foundation has been seeking to find out. The complete report of the Director of the Foundation's Department of Industrial studies is now published. Its opening explanatory paragraph is as follows:

"First impartial appraisal of Colorado Fuel & Iron Company's plan, which has been copied by hundreds of industries, declares it has remedied outstanding grievances, but does not develop leadership or interest of workmen. Report points way to termination of conflict between employees' representation and organized labor; urges Rockefeller and union to co-operate in developing more effective plan."

Since the committee have concluded that leadership and interest are the essentials lacking, it should be interesting to discover the method they adopt which successfully supplies these essential factors.

Blast Furnace Progress in 1924

A Year of Intensive Research Culminating In the Application of Several Concrete Conclusions.

By H. E. McDONNELL*

The author needs no introduction to the metallurgical fraternity.

As Secretary of the Eastern States Blast Furnace and Coke Oven Association, he has had much to do in the constructive campaign which that important organization has waged for a better understanding of fundamental problems affecting the production of iron.

The work of the Association stands out prominently as a carefully drawn pattern of careful analysis, quietly done and insistently carried on toward their definite objective.

Through their efforts the various co-operative activities which so closely link the complete process of iron making from ore onward are being drawn together in logical sequence.

WHILE the low points of 1924 from a standpoint of production and prices of pig iron were too close for comfort to those of 1921, the year had several redeeming features which may be classed as deferred profits—real steps ahead in blast furnace construction and operation that are permanent in value and were aided, rather than hindered by reduced plant activities.

These features may be classed as:

1. A definite change in sentiment in favor of blast furnace hearth diameters 20 feet and over.
2. Increased furnace output due to more careful selection of raw materials entering the furnaces.
3. More keen interest and definite progress in determining the most economical blast furnace coke from the standpoint of coal, coke and pig iron cost as well as pig iron quality and quantity.
4. Additional refinements in furnace practice.
5. Erection of new blast furnaces.

The performance of No. 6 blast furnace at the South Works of the Illinois Steel Company, has overcome whatever doubt may have been in the minds of furnace operators as to the practicability of a 20 ft. 9 in. hearth. This furnace, the first one over 20 ft. diameter in the country, was blown out May 3rd, 1924, producing in five years and seven months, 1,142,586 tons of basic, malleable, foundry iron, and ferro silicon, averaging 604 tons a day on a coke consumption of 1996 pounds per ton of pig iron for the first million tons.

No. 5 furnace at South Works was blown in, in September, 1924, with a hearth diameter of 21 ft. 6 in., and a Bosh diameter of 24 ft. 3 in. The best month's production to date was 694 average daily tonnage on 1915 pounds of coke per ton of pig iron.

Other large hearth furnaces operated in 1924 notably at Ensley, Pittsburgh and Lorain, have been very successful and several plants are remodeling furnaces with hearths 20 ft. and over or making preparations in their rebuilds for possible future enlargements up to 22 ft. hearths and 25 ft. boshes.

Due to the enlargement of furnaces, improvements in equipment, design and raw materials and general advance in furnace practice, 1924 has witnessed several plants producing the largest output of pig iron per furnace in their history.

Several furnaces have increased wind volumes with more carefully selected materials and have attained heavy tonnages, which show the possibilities of such practice were such materials always available.

The use of blast furnace turnings to enrich the ore mixtures, has been greatly retarded by the increase in scrap price, and lower costs and satisfactory tonnage are being made on improved ore mixtures that will support higher wind and higher blast temperatures.

The past year has seen greater efforts than ever on the part of furnace interests to work out the problem of the most economical coke plant and blast furnace practice for their own individual requirements.

The successful coking of 100 per cent high volatile coal and molding of furnace practice to accommodate the resulting coke offers economies that call for the best efforts on the part of coke plant and blast furnace operators. Where for local reasons the use of straight high volatile coal does not produce results that are ultimately economical, it has become the problem to assemble coal mixtures that will get the required results for the least money.

In the 24 years from the time of building the first by-product ovens producing blast furnace coke, in 1892, to the beginning of 1916, there were only 14 companies who controlled their own byproduct coke plant and blast furnaces, whereas in nine years from 1916 to date 26 additional companies operating blast furnaces have installed their own coke plants.

In other words the year of 1924 witnessed 40 instead of 14 companies making their own coke in by-product ovens for their own furnaces with all the possibilities of making coke economically and to their own liking according to their own particular local requirements.

As judged by blast furnace results, by-product ovens have brought home in a way that was not so evident with coke from bee-hive ovens, that blast furnace economies can be regulated as far back as the coal mines and the flexibility of the mines, coke ovens and blast furnaces taken as a unit are seen to offer economies in ultimate production never as evident nor on so great a scale as in the year just passed.

Greater attention is consequently being paid to coal quality and mining practice as influencing the cost, quantity, and quality of pig iron.

The fact that an increase of 1 per cent ash in the coal can increase the cost of pig iron by 31 cents a ton, was pointed out by Mr. L. A. Forrest of the

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*Superintendent Blast Furnace Department, Weirton Steel Company, Weirton, West. Va.

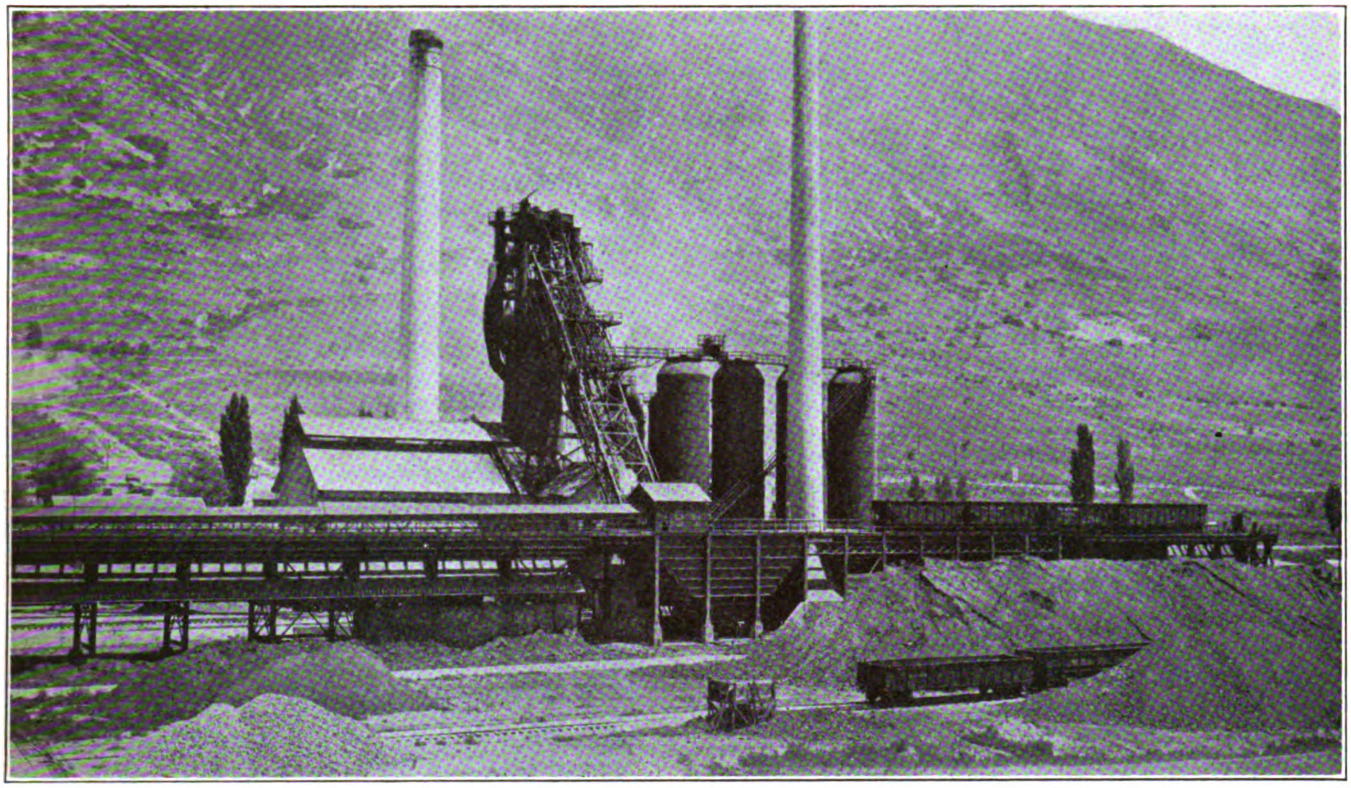


FIG. 1—*The latest addition to the blast furnace industry. This furnace located at Provo, Utah, was blown in early in 1924 by the Columbia Steel Company. By-product coke is supplied from 33 Becker type ovens which have solved the problem of coking high volatile Utah coals. See January issue of Blast Furnace and Steel Plant.*

Semet-Solvay Company, Syracuse, N. Y., in a paper read before the Southern Ohio Pig Iron and Coke Association in Columbus last October, while on the same day Mr. D. L. Ward, general superintendent of the By-Product Coke Corporation of Chicago, presented a paper before the Eastern States Blast Furnace and Coke Oven Association in Pittsburgh, giving figures to show that a company operating its own coke ovens and blast furnaces had discovered a loss of over $4,000,000 in two years due to the purchase of a coal for coking that was 15c a ton cheaper than another that had been giving satisfactory results.

The effect of variable coal quality on furnace operation and the necessity of closer co-operation between the coal mines, coke plants and blast furnaces has been very ably stated by Mr. Walter Mathesius, superintendent of Blast Furnaces at the South Chicago Plant of the Illinois Steel Company in a paper read last May before the American Iron and Steel Institute.

His illustration of the variation of ash in the coal as mined, and the consequent variation in the quality of coke produced, explains the introduction of irregularities into the blast furnace operation due to variable coke that even extreme alertness on the part of the furnace arganization cannot always overcome.

It may not be out of place to quote liberally from Mr. Mathesius paper.

"Uniformly high standard of quality demands not only governing the chemical composition of the metal so as to regularly keep its silicon, manganese and sulphur content, etc., well within the specified limits, but also necessitates the maintenance of certain physical properties of temperature, fluidity and freedom from slag emulsions. To operate furnaces in this manner it is imperative that a constant relation of hearth temperature, slag analysis and slag volume be rigidly preserved. It will be readily understood that any disturbance of the equilibrium between these factors must affect the quality of the iron and to prevent such changes is the preeminent task of the furnace operator.

Each one of these steps, which are collectively termed the "safety margin" of blast furnace operation, is distinctly uneconomical by virtue of the fact that their effect is not confined to the hearth reactions but involves the reducing zone as well. Increased slag volume means not merely more melting but lower production, because the slag-forming materials occupy, in the furnace stack, space which otherwise would be available for the reduction of iron ores. Higher slag basicity requires not only a higher temperature for the reduction of an equal amount of silicon into the metal bath and an accordingly greater heat input, but entails also a higher average stack temperature, which in turn means a greater heat loss by reason of an increased heat content of the furnace gases rising from the hearth and not met in the stack by a correspondingly higher heat demand.

Uniformity, as the keynote to blast furnace success, has been sounded so frequently in recent years as to almost appear commonplace to many men not directly connected with furnace operation. Those, who have been fighting in the apparently incessant struggle for its attainment, hope to see the day when it will really deserve that name through universal acceptance of its principle as an absolute essential, not only in their own limited field, but in all of the contributory industries as well.

It is a pleasure to compliment here the understanding on the part of the iron ore trade for the needs of the blast furnace industry. The comprehensive system of mining, sampling, mixing, grading and shipping ores, which is now most generally applied to an enormous volume of business transacted year by year, is an unqualified success .

For the limestone trade it may be said in this respect that gratifying improvements have been made during recent years, but that in many instances it is still several laps behind its big brother, the ore business.

In keeping with these tendencies, commendable progress has been made toward perfecting blast furnace blowing equipment, so as to obtain a definite volumetric efficiency and accurate speed control.

In marked contrast to this constructive development stand today the conditions which still exist in and largely govern the manufacture of blast furnace coke.

A wide range of irregularity is in fact the outstanding feature of the blast furnace fuel supply at a majority of plants.

1—Coke ash is as a rule of a silicious nature and through combination with the fluxing materials becomes during the melting process a part of the blast furnace slag, in exactly the same way as other nonmetallic constituents of the burden. Variations in coke ash, therefore, cause a disturbance of the hearth equilibria and accordingly affect the blast furnace process just as has been described at the beginning of this paper with reference to raw materials generally.

2—Coke is in the blast furnace burden the principal source of sulphur, the satisfactory elimination of which in the furnace hearth requires a definite combination of temperature, slag composition and slag volume. With temperature dictated by pig iron specifications, it is obvious that sulphur entering the process in excess of the amount which the available slag volume of a given basicity can absorb, is transferred to the metal, reducing its sales value or its usefulness for steel making purposes.

3—Every variation of the ash content in the coke is necessarily accompanied by a corresponding change of its carbon percentage and fuel value.

4—Irregular ash content of furnace coke denotes variations in the composition of the coal from which the coke was produced.

There is only one possible remedy, and that is the regulation of the blast furnace fuel supply in accordance with the principles of the iron ore trade, so that as nearly as this can be accomplished with our present knowledge and ability, every coke charge entering the individual blast furnace may within a given weight and volume convey into the process the same fuel value with the same chemical and physical characteristics.

In a recent paper presented to this Institute on modern methods of mining coal, the author describes interestingly and endorses fittingly the efforts and the success of the coal mining industry toward safer mining, lower operating costs, increased application of mining machinery and especially toward greater coal recovery from a given acreage of coal land. No mention is made, however, of possible developments in mining practice which might enable or promote a better economy in the utilization of the fuel.

Most pig iron producers who are not at present enjoying such advantages in the operation of their plants can point to past performances under more opportune fuel conditions with a pride in which it would be eminently fitting to allow a liberal share of credit to the coke plant and the mine management. But steeled rather than wearied by their years of struggle for uniformity's sake, blast furnace men stand ready to surpass their records. To this end they solicit the earnest and hearty co-operation of the coal mining man".

As regards blast furnace practice, we find in 1924 several refinements leading to increased production and cheaper pig iron.

The distribution of materials in the furnace top are being given even greater attention than ever and revolving distributors are becoming more generally used, most of the recent furnaces including these in their original construction.

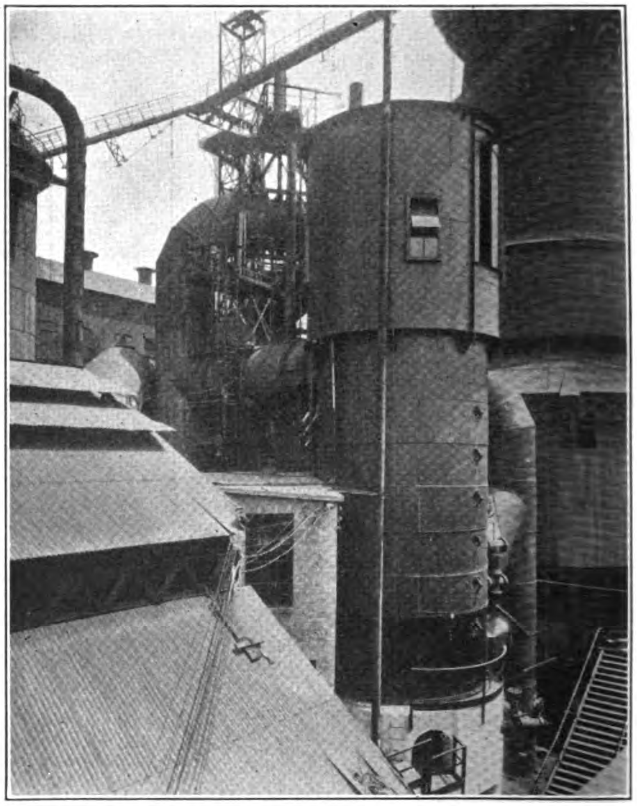


FIG. 2—*Shows the Feld gas scrubber in location. The unit is 16 ft. in diam., and is provided with 7 chambers; it is superimposed on a 30 ft. diam. Dorr thickener. The double-stage method of operation allows re-circulation of dirty water in the lower or "dust" stage, which accounts for water consumption as low as 13-16 gallons per M.C.F. gas varying with the seasonal temperature.*

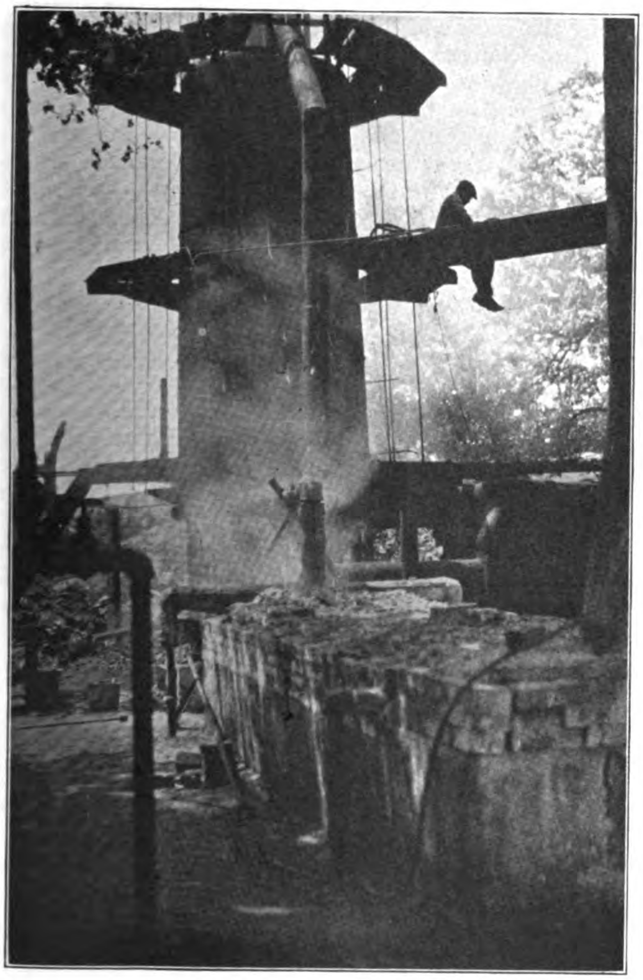
With the revolving distributor and the independently built skip incline from which the furnace bells are hung, a recent furnace has overcome the danger of poor distribution due to the movement of the bells off center by swinging the bells from a head frame secured to the furnace shell, so that the revolving top and bell suspension are part of the furnace structure, and independent of any movement of the skip incline, removing thereby any objection to the independent skip.

The successful cleaning of furnace gas opened up such a wide field for the increase of stove heating surface due to the ability to use very small checker openings with the narrower checker brick that the effort toward high heating surface was in several instances carried to extremes to the extent that structural strength was somewhat sacrificed to high heating surface.

There is a marked tendency at present to have larger checker openings and stronger brick which give a stove a greater strength, longer life and enough free gas passage to yield high heats at the same time.

The installation of pressure gas burners on hot blast stoves has in several instances given heat results that indicate that carefully regulated burning of the gas in stoves will more than compensate for any sacrifice in heating surface in the interest of strength.

Where power demands are heavy, the more economical use of furnace gas is imperative and pressure burners on stoves and boilers have shown greater efficiency and have yielded higher gas credits in the cost of producing pig iron.



View of experimental furnace at the University of Minnesota. Observer determining "reduction zone" with water-cooled gas-sampling tube.

The Bureau of Mines issued a series of papers covering the results of months of research which was centered about their Experimental Furnace at the University of Minnesota. A good view of the actual furnace during operation is shown herewith. The complete papers by P. H. Royster, T. L. Joseph, and S. P. Kinney, were published in the Blast Furnace and Steel Plant beginning January, 1924, and concluding in June. Much valuable and interesting data form a part of this research. A number of definite conclusions were reached, which, whether concured in by blast furnace men in toto; or not, at least, form a basis for active controversy.

With increasing cost of coal, further improvements in gas burning may be expected.

The newest arrival in the field of gas cleaning is the Feld Wet Washer built by the Bartlett-Hayward Company, and installed last spring at one of the United States Steel Corporation's blast furnace plants.

A vertical tower 16 ft. in diameter and 40 ft. high is fitted with a vertical, central, motor driven shaft to which are attached concentric cone frustums which elevate and spray the washing water in different stages.

Results show so far, a very high efficiency, with exceptionally dry gas and a notable saving in water, the latter greatly helping to offset the cost of operation.

The Feld Washer as installed was built over a two stage Dorr thickener of high settling efficiency.

The Brassert wet washer continues to clean blast furnace gas satisfactorily for stoves, and boilers at a minimum of operating and maintenance cost.

A stove of 95,000 sq. ft. heating surface with 3½ in. checker openings was entered after 13 months of continuous operation on gas cleaned in a Brassert Washer. The checker flues were so clean as to not require brushing, and the brick on the side of the flue where the gas flow impinged showed clearly the brand mark of the brick and almost the original color.

However blast furnace plants operating wet washers are still faced with the aggravating and, to date, unsolved problem as to the economical and satisfactory handling and disposal of flue dust carried out with the gas washer water, one of the most serious obstacles in the way of wet washing.

Whether the loss of sensible heat in cooling the gas by wet washing is not offset by the lowering of the final moisture content in the cold gas due to condensation, is still open to some question.

The moisture in the raw materials charged into the furnace is almost entirely carried off in the gas delivered to the stoves and boilers, and forms a dead load to such an extent that if not reduced in quantity by cooling, its lowering of the flame temperature and heat transfer of the burned gas must be carefully considered when it is compared to the uncooled gas.

The increased efforts to deliver a constant weight of air blown into the blast furnace have taken the form of more accurate governing of existing blowing equipment as well as special efforts toward uniformity in new installations.

The reduction in the amount of flue dust produced and the consequent decrease in the ore cost due to uniform as against irregular blast can easily effect the cost of pig iron by 10c a ton for ore alone, to say nothing of the advanatge and economy of smoother, more uniform, furnace operation.

From the standpoint of new construction the past year has witnessed the completion of one and the beginning of construction of two others, a total of three new blast furnaces.

The new Youngstown Sheet and Tube Furnace at the Mark Plant at Indiana Harbor is an addition to the already existing furnace plant but the Columbia

(Continued on page 72)

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The Electric Furnace Rennerfeldt

A New Disposition of Electrodes Adds Distinct Operating Advantages.

Translated by H. ILLIES*

THE electric arc furnaces can be distinguished according to the manner in which the transmission of the heat of the arc to the charge is done, in the two main groups of furnaces with direct and with indirect heating. The arc is formed at the latter, independent of the charge above it, and immediately between the electrodes, which are inclined under a certain angle against the horizontal line. The transmission of the heat is done only by radiation, and, therefore, these furnaces are called radiation furnaces.

At the furnaces with direct heating, the arc is generated between the vertical electrode and the bath, so that an immediate heat transmission takes place. Each of the two kinds of heating is characterized by special properties in regard to the operation and the effect on the charge, and, therefore, one or the other of the two systems will offer special advantages. The Rennerfelt furnace makes it possible to work as well with direct as with indirect heating, and unites in a happy manner the advantages of both kinds of operation.

An incontestable and generally acknowledged advantage of the radiation furnaces consists in causing a load on the line proportionally free of pusher, as also in melting scrap larger pushes of the current are avoided on account of the independency of the arc from the melting charge. In metallurgical regard, the radiation furnace is also superior to the furnace with direct heating in many relations, as on account of the equal distribution of the heat the danger of local overheating of the bath and the injurious gas reception, on account of this superheating, is decreased. Also, the possibility of a not-desired carbonizing of the bath is considerably diminished, as the electrodes do not touch the bath.

It is further proven that the steel generated in an arc furnace has considerable less pollutions by slag than steel from an induction furnace, or from furnaces which work with an arc bound to the charge.

The explanation can be found in the fact that at latter process the bath is in a continuous movement on account of the electro-dynamic proceedings at the passing of the current, so that the particles of slag, which result from the incomplete reactions of the deoxidation means, are prevented from rising to the surface, and to unite themselves with the slag cover. In the American literature recently several confirmations of this observation are made.

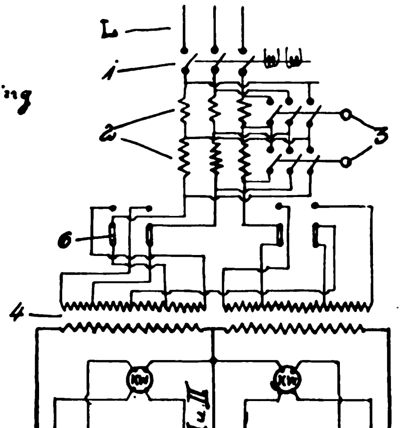
In spite of these more or less generally known advantages of the radiation furnaces, the furnaces with direct heating, especially the Heroult furnace, have found a wide spread. They are more unassuming in regard to the needed place than the radiation furnace with its three horizontal electrodes, and can be built for considerable larger charges than the latter. A disadvantage of the radiation furnace is found in the little solidity of the roof, which is deteriorated very soon, as the distance between roof and arc is proportionally smaller. This distance is larger at furnaces with direct heating, besides the roof being protected by the shade effect of the three or four vertical electrodes.

At the construction of the Rennerfelt furnace the idea was authoritive to create a furnace which allows the use of all advantages of the free burning arc, and to avoid all disadvantages of this system in structural and operating regard. Besides the construction of this furnace should make it possible to work with an arc bound to the charge as soon as it appears desirable.

This is reached by the peculiar disposition of the electrodes, contrary to the radiation furnace with three hori-

Fig 2. Standard switching scheme.

L = High tension line.
E • Electrodes
V = Voltmeter
A : Ampèremeter
KW. - Kilowattmeter
KWT. : Kilowatt hour meter
1 = Oil switch and time relais
2 = Throttle coils.
3. = Threepole partition switch
4. - Transformator
5 = Current transformator
6. - Switch for regulating the tension.



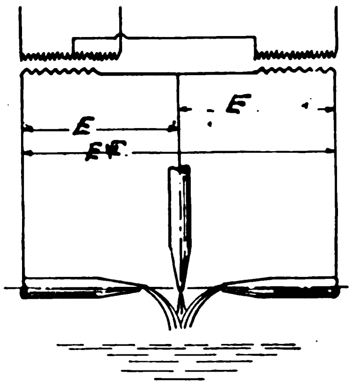


Fig. 1. Disposition of Electrodes

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*Amberg, Bavaria.

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zontal electrodes, the Rennerfelt furnace possesses only two horizontal electrodes and one vertical roof electrode. The side electrodes swing under a horizontal arc, the roof electrode can be moved in vertical direction and it is possible by a corresponding installation to adjust the arc in any height, and to work in the deepest position with the arc bound to the charge. It is, therefore, possible to employ the most fit manner of operation in each stage of the melting and refining process.

The standard proceeding in the production of refined steel or high valued steel castings in using cold scrap is as follows: The electrodes are brought into the highest position during the charging period in order to make it possible to put in the whole charge. By this a special advantage over the radiation furnace with vertical arc is obtained, as these furnaces have to be charged several times, causing heat losses. During the melting process, it is worked with free burning arc, and the electrodes are let down according to the melting down of the charge. The whole charge being liquid and the additions for forming the slag are given, the electrodes are lowered upon the bath, and the furnace is driven with alternating current and with an arc bound to the bath like a standard Heroult furnace. In this moment a good mixing of the bath is desirable in order to prepare the necessary reactions. At the end of the process the first switching is again used, the arc burns free above the bath, and this one can quietly rest, so that the slag particles, which are mixed in the bath, can be separated.

In electrical reference the standard installation of a Rennerfelt furnace is remarkable by the transformator aggregate, which consists of two one-phase transformators being put in the circuit by the system Scott, Fig. 2. The transformators can be put in the circuit so that the alternating current, conducted from the high tension side, can be transformed into alternating current or into two-phase current. The regulation is very simplified by the application of two-phase current. As the active intensity in the furnace depends only on the intensity of the current of the two side electrodes, only these need to be regulated. Who knows the difficulties of the hand regulation of these electrodes from own experiences will understand the advantage of this simplification without further explanation.

If J equals intensity of current in each of the two side electrodes, the intensity of current in the roof electrode = J$\sqrt{2}$. On the primary side all three phases are always equally loaded. In case that the phase tension, which is generated by the cones one-phase coil of the secondary side of the transformator connected with the alternating net—E, so is the difference of tension between rool electrode and side electrodes also—E, and the difference of tension between the two side electrodes—E$\sqrt{2}$ (Fig. 1).

Where existing standard alternating transformators shall be used or where special value is put on simple and cheap installation. It can naturally also be worked with three phase current, but in this case the roof electrode has to be regulated.

For the automatical regulation the known electrical systems of Fuss or Thury can be employed and also hydraulic regulators have proved themselves satisfactory.

Throttle coils are provided at the standard switching for moderating the current pushes, which are unavoidable at electric furnaces, whose inductive effect is about 30 per cent of the transformator effect and which are disconnected gradually.

At the beginning of melting a cold change the throttle coils are put in the circuit with standard effect. In most cases it will be possible to put out of circuit part of the throttle coil after 10-15 minutes and in further course of the charge the total throttling. The transformator effect approaches then the value expressed in kva., as the phase shifting, which is caused by the furnace operation itself, corresponds to a value.

The arc tension amounts usually at two-phase current to 100 volts. The tension is decreased to about 80 volts at switching to three phase current. The above mentioned tensions are used at smaller furnaces in order to decrease the length of the arc. At very large furnaces also with higher tensions of 120-125 volts can be operated. The higher the tension the smaller become the intensities of the current, the diameter of the electrodes and the dimensions of the structural parts, which bring about the passage of the current. Also the operation costs are decreased at the application of electrodes of smaller diameter, as the burning off is directly depending on the diameter of the electrodes. At the same time also the machanical solidity is decreased so that certain limits have to be kept.

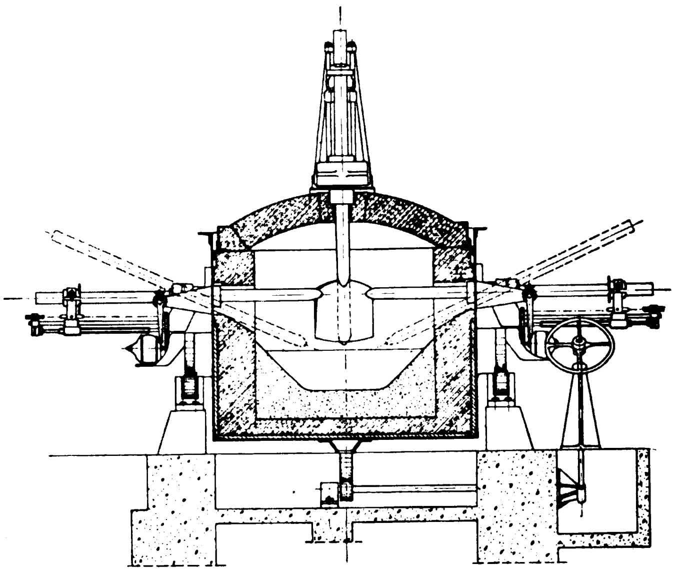
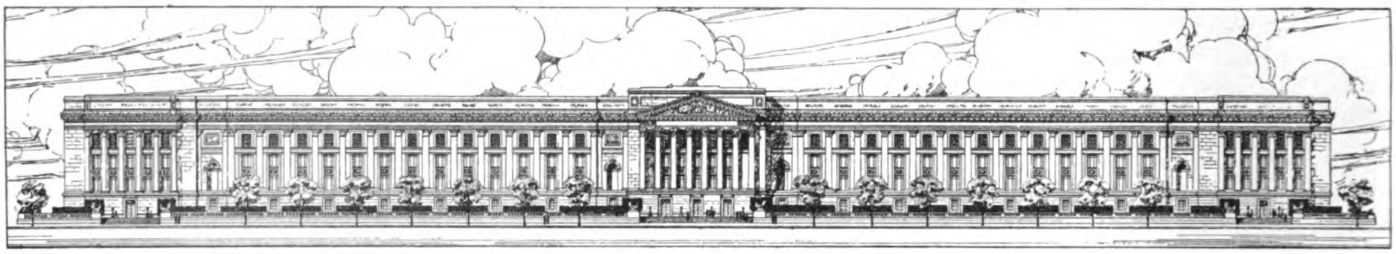


Figure 3. Section through the Rennerfelt furnace.

At a furnace of middle size at which the arc tension at two-phase currents amounts to 100 volts the tension will amount to only 80 volts after switching to three-phase current. If the electrodes are lowered till they read the charge, the tension between the elctrodes and the charge is only 80$\sqrt{3}$—about 47 volts. The effect of the transformator is at the same time decreased, so that generally about 80 per cent of the standard effect, calculated by the use of two-phase current, is used at the application of three-phase current. This decrease of the transformator effect corresponds with the demand of force of the furnace as the total transformator effect is no longer necessary after finished melting of a cold charge. It is even not advisable to work during the refining period with full application of force, because the furnace chamber in this case reaches such a high temperature that the brick lining is endangered, if the supply of force is not cautiously regulated.

The resulting arc is distinguished by a characteristic shape which is deviated toward the bath. This deviation can be declared by the influence of electro-magnetic forces on the current between the electrode points, as the appearing currents create force line fields, which act against each other at horizontal electrodes, while the force line fields of the vertical electrode is not annulled by the opposite field. In the Rennerfelt furnaces, at least in the small and middle types as well, graphite as coal electrodes can be used. At larger furnaces it would be excluded to use coal electrodes, because the quality of them is deteriorated in a high degree with the increase of diameter. Besides the allowable specific load sinks with increasing diameter so that extremely large dimensions have to be used at larger effects. The allowable load of the graphite electrodes amounts to about 40 amp. at diameters of 4 in., at larger diameters to 25-30 amp. per gcm. It can be counted with 12-15 amp. at smaller and with 5-6 amp. per gcm. at larger coal electrodes. The shape of a Rennerfelt furnace has been changed in the course of the years. The final shape of the Rennerfelt furnace has a cylindrical surface, which is covered with a removable roof, Fig. 3. The tilting is done around a horizontal arc and at small furnaces by hand wheel, worm gear and gear segment. At larger ones by electrical motor.

A Classic Addition to Washington's Growing Group of Magnificent Public Buildings



The $5,000,000 National Museum of Engineering and Industry, to be erected on the Smithsonian Institution grounds on The Mall as a companion building to the natural history museum and the gallery of fine arts, the classic structures erected in harmony with the new plans of the Fine Arts Commission, designed to make Washington the world's most beautiful capital city. The new museum will house exhibits depicting the dramatic evolution of engineering and the industries and will be the first national institution in this country devoted exclusively to recording industrial progress. It will be 1,150 feet long, 250 feet deep and cover 27 acres of floor space. The great central rotunda will house a Hall of Fame for eminent engineers, inventors and industrialists and a Founders' Room to commemorate those who will have contributed to the museum, in time, money or effort. A public building and endowment fund of $10,000,000 is being raised from the present headquarters of the National Museum of Engineering and Industry in the Engineering Societies Building, 29 West Thirty-ninth Street, New York City.

Blast Furnace Progress in 1924

(Continued from page 69)

Steel Corporation furnace plant at Provo, Utah, and the Mystic Iron Company's furnace plant at Everett (Boston), Mass., are entirely new plants each having the distinction of entering entirely new territory.

The site for the Columbia Steel Corporation's furnace was fixed by the location of the large ore and coking coal deposits in the vicinity of Provo, Utah, and by the comparative closeness to the Pacific Coast markets where Columbia basic and foundry iron has already become a decided factor. Their chief competition is from European, especially Belgian, blast furnaces.

The furnace, which was blown in, in April, 1924, is producing about 370 tons a day of basic and foundry grades of pig iron with a coke consumption of 2,250 pounds per ton of pig iron.

Local high volatile coals are coked in the company's by-product coke plant consisting of 33 Koppers Becker type ovens.

The local ores of which 15 per cent to 20 per cent are magnetite average 56 per cent iron and 7 per cent silica, natural.

The furnace has a hearth diameter of 15 ft. 0 in., bosh diameter of 19 ft. 0 in., height, 83 ft; 8 tuyeres, McKee revolving distributor, four stoves of 4½ in. checker opening with 50,000 sq. ft. heating surface each, operating on gas passed through a Brassert Washer.

Ingersoll Rand turbo blowers deliver the blast.

The stock bin and stock house construction has allowed uninterrupted filling of the furnace this winter in temperatures from 30 deg. to 36 deg. below zero.

The Mystic Iron Company's furnace at Everett, Mass., complete with ore docks and unloading equipment is of medium size and is to operate on foreign ores, using coke from the New England Fuel Company's existing by-product ovens, which at present are selling their coke to the foundry and domestic trade.

Situated on the Atlantic seaboard in the heart of the New England pig iron market and with the freight rate on pig iron from eastern furnaces to New England at $3.50 a ton, the furnace has an ideal location.

No summary of blast furnace conditions would seem complete without reference to refractories.

It is interesting to note the activity of refractory manufacturers during the past year; unusual stress being laid on producing blast furnace brick more nearly uniform in dimensions. The problem to overcome is that of keeping the dimensions uniform while burning the material at sufficiently high temperatures, it being generally understood that hard burned brick are required for blast furnace work. We believe that considerable progress has been made in this direction.

Of the linings purchased during the past year, it is estimated that over 95 per cent were what are known as "Steam Pressed" or "Machine Made." This is in line with the steady decrease in the use of "Hand Made" linings of former years.

The use of refractory cements seems to be increasing, it being estimated that such cements were used in parts or in entire linings of approximately 40 per cent of the furnaces relined during the past two years.

THE SAFETY CRUSADE

Cost of Fatigue in Steel Plants

Unusual Results Have Attended Various Studies Into This Form of Waste

By **HAYNES PORTER**[*]

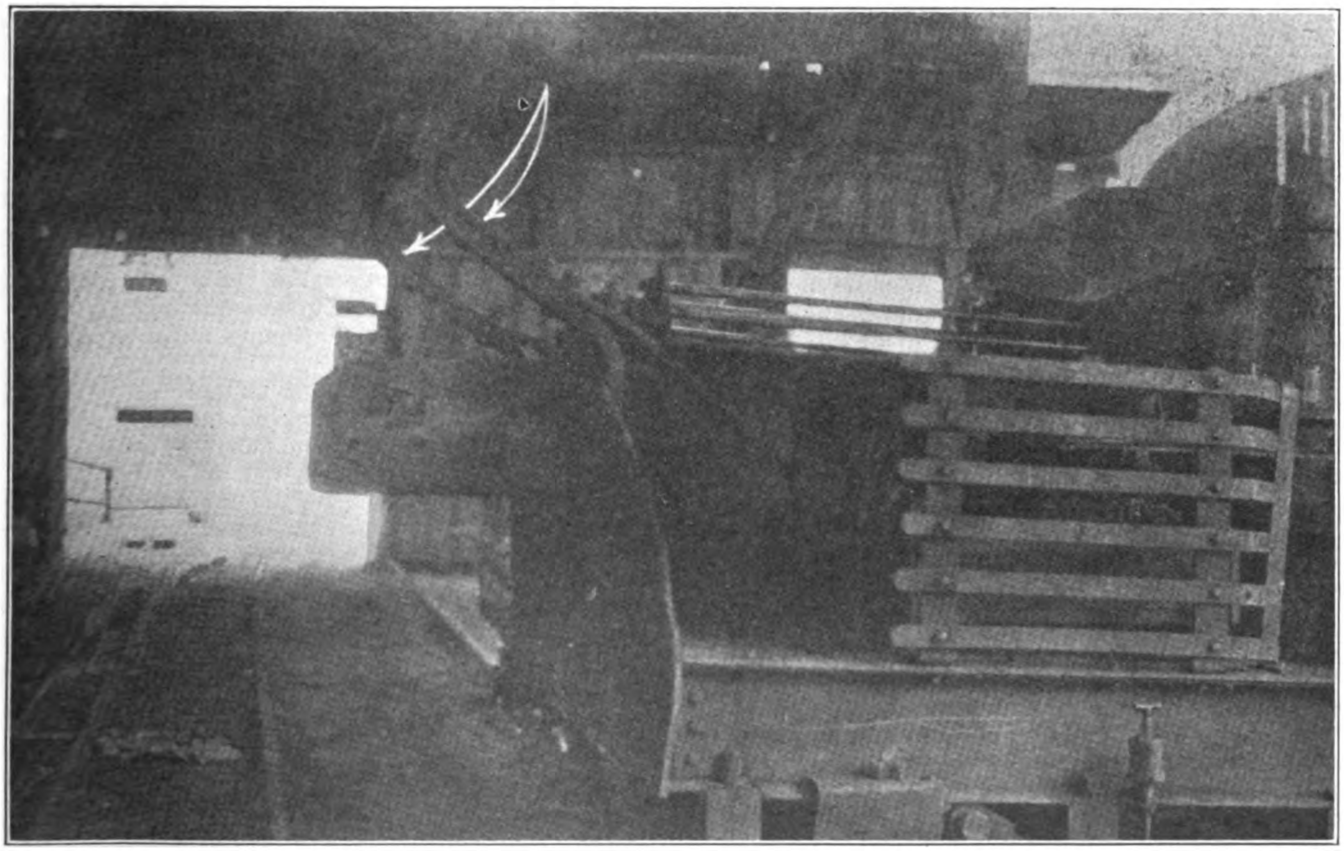
RECENT studies of fatigue among operatives in steel mills and other industries throw considerable light, not only on the causes and processes of bodily fatigue but also upon the losses in dollars and cents which result from the failure to apply the simplest remedies at hand.

Probably the steel industry suffers as much from this unnecessary waste as any other trade employing large numbers of manual labors. And while some study has been given this question by a number of the largest mills and plants, progress of a practical nature also has been made in the work by outside students interested chiefly in the scientific aspects of the question.

The time has passed when the large steel plant can ignore accepted and proven principles of personal efficiency and it is safe to say that the present provisions for correction of fatigue are keeping fairly apace with the increased knowledge on the subject.

However, so unusual have been the results of applied study on this subject proven to be that too much information in simple form can scarcely be published. From purely profit and loss standards the correction of unnatural and useless fatigue among operatives is highly important and we have ample statistical matter to back up this contention.

Every plant superintendent — every foreman — knows what fatigue is and can easily distinguish it from normal weariness if he tries. It is something



ONE OF THE MANY REASONS WHY

Joliet keeps on making safety records; this time 2,788 men worked through 89 days without accident. The figure shown above with the explanation indicates why—the men themselves have the right attitude. At the suggestion of Dan Moriarty, a heater in the Billet Mill, this safety ingot tumbler was installed on the charging machines. Note the heavy steel rail frame on the end of machine; before its installation, the chargers tipped the ingots toward the furnaces and against the furnace doors loosening the brick-work with danger of injury. The frame prevents the ingots striking the furnace at all.

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[*] New York City.

very different from "laziness" and should not in any way be confused with individual characteristics. It is found in a greater or less degree in every shop and is not always present most menacingly where manual labor is the hardest. It is present in the plant office as well as in the shop and the same corrective devices are applicable to brain workers as well as to puddlers.

It is not the purpose of the present article to go into the more scientific details of fatigue study in the industry, but to briefly point out in general terms, the more general factors accepted in the light of the most recent studies. It is believed that some information dealing in general with various forms of fatigue among operatives will give a proper background for a more extended study of correctives, to be taken up later.

In every shop, a close study of workers on the job reveals the fact that a great many useless movements are made in the performance of the work done. It has been the great aim of management in the larger plants to eliminate waste motion by a systematic education of the operative individually and where this plan has been applied and adhered to there has been a surprising upward curve in the production chart, per worker and in the shop as a whole.

In fact, the first effort directed to this end — the elimination of useless bodily movements — has to do with the elimination of such useless movements. The diversion of this wasted power to useful effort will, quite naturally, result in greater production per hour.

Possible to Measure.

There is a minimum number of motions which are required to perform any given job in the shop and the most progressive foremen and superintendents have these carefully noted down in their proper sequence and see that workers are following along the main lines of such schedules. The best way to attain these standards is to make tests with the best operative on a given job and correct his worst faults. The result should be a fairly accurate standard of "measurements" for that job.

It always has to be taken into consideration that fatigue resulting from a day's occupation effects certain types of operatives differently from others. A careful study of waste motion will not increase production per worker beyond his actual capacity, without drawing on a reserve which, in time, wears him out altogether. For this reason, it is not possible to greatly increase individual production by the correctives suggested above; but it is possible to make the average worker's production less wasteful, in his own interests and in that of his employer.

To test the results of fatigue correctly in any of our workshops is difficult owing to the fact that fatigue is an after effect of a cause and it will be more easily read in the actions of any group of operatives during the noon hour or after work hours than during the busy periods of the day.

Our operatives, working at high tension, do not, as a rule, show their fatigue while the interest in the job is at its height and they are preoccupied with responsibilities of the moment.

One of the leaders in the industry said not long ago that fatigue is noted among his workers chiefly by a lack of pep immediately after a day's labor. By lack of pep he meant, he said, not so much lack of physical alacrity as he did mental depression and disinterestedness.

"Our employes who play ball with pleasure during the noon hour or after the whistle blows usually are those who are not suffering from fatigue."

There are held to be two primary causes for workshop fatigue in the trade, sufficient for the purposes of study in our average shop. One is, as pointed out above, waste motion and the sapping of physical and mental energy in such a misdirected manner and secondly, insufficient rest for recuperation. Probably misdirected energies are the prime factor. Insufficient rest period has largely been beyond the control of the employer until in the past three or four years he has adopted the rest period as a means of alleviating, in a measure, the condition of lasitude which the employe will not himself set about to correct by ample and regular hours for sleep. The rest periods are not general in the industry, however, as they should and probably will be in time. The rest period breaks up the forenoon and afternoon and has found to vastly decrease fatigue, giving the human machinery a 15-minute period, twice a day in which to restore energies for labor. It even has been found profitable from production standpoint to reduce the lunch hour in order to allow the two rest periods, shifts being accordingly arranged.

It is quite natural for foremen these days to look for a more or less uniform production among operatives, but they seldom get it. Even the most competent workers are often subject to fatigue in an advanced degree and are none the less competent for all of that. Endurance may be closely knit with skill and experience but not necessarily so as we all know from actual experience.

Probably no more important though fundamental provision has been made in the industry to fight off fatigue than in supplying places where operatives are induced to rest and relax. This was not always the case. Years ago employes were left to shift for themselves in the matter of rest; today the larger shops are not only providing comfortable chairs in which to rest but are taking step to make rest inviting.

A leading authority takes the stand that fatigue is progressive — that the greater the degree of fatigue over a period of time, the longer must be the period of rest or recuperation.

Let us take the case of an operative of normal powers working along economical lines as to waste motion. His rest, in sleep and daily rest periods should and will keep him supplied with ample energy for an average day's work. But, take another employe naturally prone to waste his energy, getting insufficient sleep and playing base ball when he should be resting, and consequently losing energy every day, he will soon find that his rest will have to be taken all at once — a three months' vacation or he may face a collapse. He has been drawing more money out of the bank than he is putting in. Deposits of energy must meet withdrawals or bankruptcy is inevitable—sooner or later.

Weeding Out Sufferers.

In many of our larger shops there is a systematic weeding out of the fatigue sufferers and this is nearly always done by watching them after the whistle blows. Any superintendent or foreman, used to handling men or women, for that matter, can spot the weary ones at a glance by the way they walk, by the expressions on their faces and by the alertness of their interest (or lact of it) in things.

Perhaps in the average plant, no greater pains than this need be taken in the matter. Of course, if production slacks, this may be the result of fatigue. But it is not always easy to judge at the work bench or the machine, as pointed out previously.

The thing is to arrive at the cause of fatigue, whether it is physical defect, an abnormal lack of stamina or either of the two primary causes discussed above; that is, waste effort or insufficient period of recuperation between work periods, be it one or both.

Rest in the industry has ceased to be a butt for ridicule and there is a clear decreasing difficulty in getting over to operatives.

Quite naturally, some sort of "history" of operatives is necessary in advance so that their natural stamina may be guaged and that congenital lack of endurance may not be taken for waste motion or carelessness in regard to rest periods, either at home or at the plant.

What has come to be called good or bad "work habits" has interested a good many foremen in recent years and they usually mean nothing more nor less by the term than the ability of one man to form work habits which involve the minimum of energy with the maximum of results. It has been demonstrated that it is possible to instill these good habits of working by paying attention to employes individually and persistently encouraging them to adopt the best way to do a given performance in the minimum time and with the minimum effort.

What the industry looked upon with doubt and often ridicule 15 years ago, is now an important part of plant administration and the end is not yet. This matter of personnel and close attention to fatigue is just enough in the balance of the scale to make one plant more profitable than another and the operatives of one shop a better class of workers than in the other.

After all, the "investment" in human labor has to be conserved and while a lot of us may think lightly of many of the theories of "efficiency experts," this matter of the wastes in fatigue should never be confused with the more advanced notions of students. Conservation of human energy is as important, or more so, to the superintendent as conservation of his power plant.

Certainly, the steel industry requires as careful conservation of its human energy as many other industries which give it more attention. The work is peculiarly trying for the most part and while the trade suffers considerably from a heavy labor turnover, it still is possible to not only apply more far reaching studies of the fatigue and labor conservation questions and to make these very studies and their application decrease labor turnover at the same time. After all, absenteeism is largely a matter of faulty working conditions where it is abnormally high and in plants where correctives to fatigue have been applied, they have reduced both absenteeism and turnover.

The Struggle Against Waste in Business

"Simplification" Will Save Millions for the Nation, Says Commerce Department

"While we currently assume that great advancements in living standards are brought about by new and basic inventions, an even larger field for advancement of those standards is found in the steady elimination of our economic wastes," declares Secretary of Commerce Hoover in a foreword of a booklet entitled "Simplified Practice—What It Is and What It Offers," which has just been issued by the Division of Simplified Practice, Department of Commerce.

"The necessity of maintaining a high-wage level requires that all processes of manufacture and distribution be reduced to the lowest possible cost," continues the foreword. "This can be done through the elimination of those wastes arising out of too high a degree of diversification in certain basic products. Today dozens of different sizes, styles, types and patterns of the most commonplace articles are placed in the market by manufacturers who must possess special equipment and skill to produce these endless variations. Merchants accumulate great stocks, which turn but slowly because of the excessive diversity and lack of interchangeability in their components. Because of this situation many manufacturers and distributors favor co-operation for simplification and standardization.

"The saving in national effort through such co-operation as demonstrated by many well known examples of simplification and standardization, runs into millions of dollars. There is a great area still untouched, in which the application of these waste-eliminating measures may well save not millions, but billions. * * * The rate of our advance must be, and will be, in proportion to the extent in which we all co-operate for the elimination of waste."

Government co-operation is needed in simplification, it was pointed out, because of the feeling among manufacturers that they might not properly approach either distributors or users of their commodities with such a proposal; also because distributors and consumers are of the opinion a reduction would be beneficial if other groups would agree. This was the reason for the Division being established to serve as a clearing agency to offer co-operation in analyzing problems and bringing all groups of an industry together to take concerted action at the request of any group.

Advantages of the co-operative action have been proved by the experience of industrial groups which have undertaken simplified practice and have weeded out those styles, types and patterns of commodities which were not in active demand, it is shown. Some of the immediate benefits have been the reduction of stocks, selling and production costs, misunderstandings, as well as costs to the user, both as to initial expense, accessory, and maintenance. Along with these has come an increase in turnover of stocks, stability of employment, promptness of delivery, broadening of market, and improvement of product at the same time profits to producer, distributor and user were being increased.

The progress of Simplified Practice is shown in 25 industries which have achieved simplification; and the 40 or more simplifications which are now under way with the co-operation of the Division.

Considerable space is devoted to a discussion of the experience of various groups in achieving simplification (whether as individuals or small groups) and the efforts of trade associations in developing and supporting simplification programs.

Further consideration is given in chapters devoted to the gains achieved by the manufacturer, the wholesaler and retailer, and the consumer, and it is shown how simplification may well be a step toward the development of standards.

Engineering Achievements in 1924

A Resume of Many Westinghouse Developments Important to Iron and Steel Production.

By H. W. COPE*

THE idea that the large companies at the end of each year gather and take stock of developments of what has been done and achieved is a very commendable one, and many items of interest are to be found by such a review.

Reviewing the engineering achievements of the Westinghouse Company for the year 1924 we find many noteworthy developments. The advancements can perhaps not be characterizd as being of a fundamental nature to the art of electrical engineering, but as a whole a steady progress is noted in every field along this line of endeavor.

General Trend—Growing Unit Sizes.

The tendency in building turbines, turbo-generators and converters lies in the direction of increasingly larger units, involving a great many manufacturing difficulties as machine shop handling, tools and shipping. There does not seem to be any inherent limit to the unit sizes from an electrotechnical standpoint, and a limit in increase of size of units will probably be met by economic factors giving the best co-ordination for attaining lowest cost of operation.

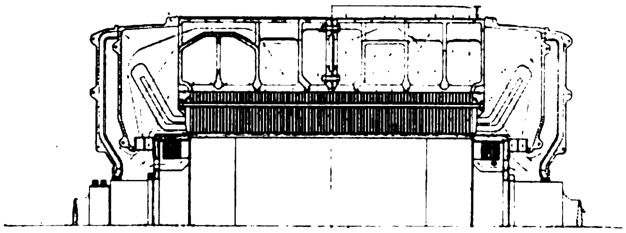

FIG. 1—*Westinghouse new type multi-radial ventilating system for turbo-generators.*

Vibrations and Support of Machinery.

The increasing size of units, together with high speed of their moving parts, introduces, however, serious difficulties arising from imperfect balancing.

A simple and effective balancing machine for accurately balancing high speed machinery up to the largest rotors the manufacturer is called upon to build has been perfected, and thus power losses are minimized. A very effective spring support has been devised for the purpose of damping out the vibrations of machinery caused by the pulsating torque producer, for instance, by single phase power.

Machine Control and Labor Saving Devices.

Switching equipment of the truck type and high speed supervisory control systems, enabling quick control and indication of remote breaks as well as selective remote meter readings and the synchronizing of feeder circuits has been placed in operation and are becoming very popular. Improvements along this line have resulted in operating the machinery better than when under manual control.

Refinements.

Among what may be termed refinements we note such things as the Inertaire transformer, radiator valve for self-cooling transformers, a dehydrating breaker for transformers, and a flow indicator for water-cooled transformers. Further a sealed sleeve bearing for industrial motors has been successfully developed. Under this heading would also come the numerous refinements in details of design of standard machinery and apparatus which will be found of special interest to the steel industry.

Steel Mills.

The most remarkable feature of the electrification of steel mills has been the large number of orders received during this year of comparative dull times for the steel industry. This fact is a most striking indication of the economy and reliability of electric operaton.

Five reversing equipments have been sold, including two large reversing blooming mills, two roughing structural mills and one finishing structural mill.

One of the greatest advances in the art was made this year when the company placed in operation a 5,000-hp., single unit reversing mill, which received its power from two 2,100-kw. generators operating in parallel. It has heretofore been considered necessary to drive one motor from a single generator, and if two motors were used, two generators were required. By this new arrangement, it is possible to design both motors and generators to best meet their operating condition, rather than to have the design determined by the number of units of which the equipment is composed. The inherent characteristics of all machines will be improved and they will perform more easily and efficiently.

A 40-in. and a 44-in. blooming mill are each being equipped with 7,000-hp. single unit motors. This constitutes the largest single unit d.c. motor ever built.

A 40-in. blooming mill and a 48-in. universal plate mill have been equipped with a 7,000-hp. double unit and a 5,000-hp. single unit, respectively.

A 24-in. structural mill and a 22-in. bar mill have been changed over from steam to electric drive.

An installation has been made in Spain, consisting of a 5,000-hp. reversing blooming mill, a 3,750-hp. reversing structural mill, and a three-high plate mill, driven by a 3,000-hp. induction motor.

Work is going forward on a 6,000-hp., 98 rpm., wound rotor induction motor to drive a 28-32-in. structural finishing mill.

A 500-hp. d.c. motor is being installed to operate at 155 to 500 rpm., at any voltage from 220 to 250. This application is for a tire mill and constitutes a speed range of 3.7 to 1, which is exceptionally high for motors of this capacity.

Motor Generator Sets.

A notable advance has been made in motor-generator sets for steel mills. This consists in the use of a single motor driving two generators connected in parallel.

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*Assistant Director of Engineering, Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

One set of this type is now in very successful operation, having capacity for a 5,000-hp. reversing mill motor. Two other sets of 5,000 hp. and 7,000 hp. capacity are under construction and will be delivered shortly.

The design of motor-generator sets has progressed so remarkably that during the year a set has been built and successfully tested, having a capacity of 1500 hp., yet of small enough size and weight to permit its being successfully mounted in the cab of an electric locomotive.

The company has built and shipped two very large current capacity d.c. machines. These involve unusual difficulty in the commutator design. One unit has a capacity of 780 kw., 65 volts, 12,000 amps., 500 rpm., consisting of a driving motor and two d.c. generators. Each commutator has a capacity of 6,000 amps., 65 volts.

The other set has a rating of 1,875 kw., 250 volts, 7,500 amps. It consists of a driving motor and two d.c. generators. Each of the latter has a rating of 7,500 amps., 125 volts.

The order for these machines was obtained as a result of the company's pre-eminence in the field of high current carrying machines for electrolytic processes.

The first large automatically controlled motor-generator set, installed in December, 1920, for supplying an Edison system and arranged for restoring service in case of accidental shutdown of the system, have been so successful in operation that their use has been adopted by other important utility companies. During the year an 1,800-kw., 250-volt motor-generator set with automatic control has been installed by one of the large eastern central station companies, and another similar set has been placed in operation in the Middle West.

Industrial Heating.

Two electric heating furnaces have been installed in wire mills. These are used for the continuous hardening, quenching and tempering of carbon steel wire. By the use of this process, the physical properties of the wire are better than when treated in a gas furnace. A bright unoxidized surface on the wire is produced. These are the first electric furnaces to successfully do this work, and thy have proved a decided economic success.

A 100-kw., 5,000-cycle, 125-volt generator has been placed in service for the power supply of an induction furnace.

A continuous type electric furnace has been installed for the hardening of the races of ball bearings.

Heat Treatment of Steel.

With the co-operation of the steel foundries, it has been possible to develop a method for the heat treatment of large steel castings in such a manner that a material equivalent to a forging is produced having a uniformity of grain structure.

There has been developed a container, salt mixture, and a quenching bath which assures extreme hardness uniformly distributed over the entire surface of the piece that is receiving the heat treatment.

Electrolytic Refining of Iron.

In order to meet the exacting requirements of certain lines of apparatus, it has been necessary for the company to go into the refining of iron by the electrolytic process. A plant for this purpose has therefore been built adjacent to the East Pittsburgh works.

Ceramics.

Very extensive studies have been made to determine the best method of firing and cooling insulator parts. This has been done to enable the company to improve its product by increasing the efficiency and life of insulators to a considerable extent.

Interlink insulators, 8 in. and 10 in. in diameter, have been brought out. These have unusually high tensile strength when fitted with suitable cable. The hole is so designed that the cabel is allowed to distribute the stress uniformly through the thick mass of porcelain, placing the latter in compression. All shear and expansion forces are eliminated.

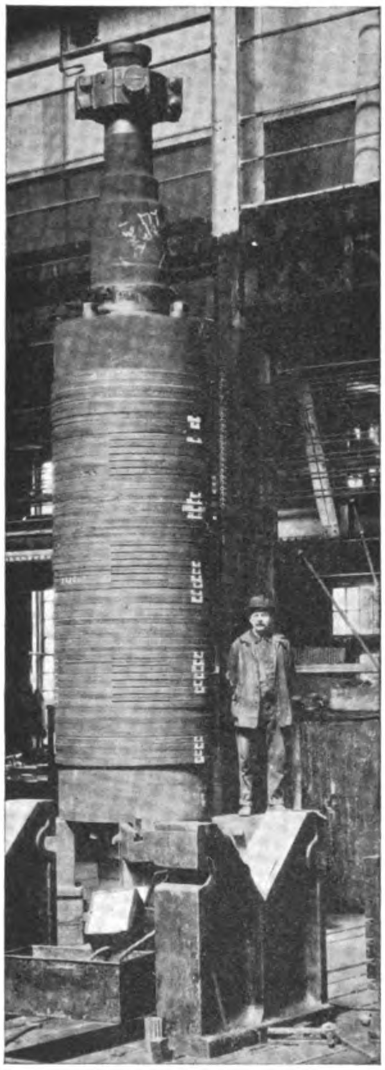

FIG. 2—*Rotor for 12,500 Kv.a. 3600 R.p.m. turbo-generator showing its extreme length.*

An improved form of pin for suspension insulators, which has increased the strength of the unit considerably, has been developed. The shape of the pin was determined after careful study of the distribution of such acid. In this work no attempt was made to study the effects of acidity, and varying temperatures, upon the rate of diffusion; it was almost entirely concerned with the effects of current density on the diffusibility of hydrogen, etc.

In 1922 G. C. Schmidt and T. Lucke gave an account of a most interesting series of experiments in which they studied the change of potential, with time, whilst the current was passing through the electrolyte, and after the current had been discontinued.

A little later M. Bodenstein worked in a similar direction, and concluded that acthodically generated hydrogen diffuses through iron in the atomic state. In an attempt to demonstrate that the gas was in the atomic condition he hoped to make it combine with bromine vapor, chlorine, or sulphur, on withdrawing it from the interior of the cathode, but met with no success. With nitrogen, however, a small quantity of ammonia was formed, and with oxygen large quantities of water.

Numerous papers dealing with the embrittling effects of hydrogen on iron and steel, both by ordinary pickling and when the gas is cathodically generated, have been made. Since, however, the present paper does not deal with this aspect of the question, those interested are referred to the original publications, and especially to the papers by Fuller and by S. C. Langdon and M. A. Grossman, in which full references are given.

The present author's attention was drawn to this question on taking up the study of the defect known as "peppery blisters", which is sometimes encountered in the manufacture of tin-plates. These blisters are extremely small, and appear on the finished sheet in large numbers, giving the surface a pimpled and rather dull appearance.

Dealing with this subject in 1901, Ridsdale[9] said: "Pickling may sometimes cause blisters on thin sheets. These pickling blisters are quite distinct from ordinary blowhole blisters, and are usually thickly distributed over the plate. They never appear until after pickling, and often come up after the annealing which follows it. Such blistered sheets are also brittle." He stated that he had sheared blistered sheets into shreds, under water, and collected the liberated gas, which consisted essentially of hydrogen. From the point of view of the present investigation, the two most interesting conclusions which Ridsdale put forward were:

> "(1) It seems probable that the grains, which in thin sheets are flattened into flakes or laminae, become separated perhaps by the action of the acid, and when sufficiently thin the film of metal is disturbed by the hydrogen either at once or by the heat whilst annealing."
>
> "(2) He had never seen conclusively explained why, or under what conditions, the hydrogen is absorbed, whether it is a question of strength of acid, temperature, or length of time, but it is quite certain that pickling does not always have the same effect."

E. F. Law conducted some useful experiments relating to these blisters, from which he concluded that:

"Oxidized steel will give rise to blistered sheets, and that this defect is more liable to occur with Bessemer than with open-hearth steel." He offers the following explanation of the formation of these blisters:

"... in the pickling bath large volumes of hydrogen are evolved, and it is well known that hydrogen is capable of entering and passing through a thin sheet of steel. Further, nascent hydrogen is a powerful reducing agent, and this hydrogen, assisted by the high temperature of the pickling bath, reduces the oxide in the steel with the formation of water vapor. The volume of the molecule of water is, however, much greater than that of hydrogen, and, therefore, is incapable of passing out of the sheet. Moreover, the volume occupied by the water vapor is much greater than the volume occupied by the original oxide, and the internal pressure thus produced is sufficient to cause an incipient blister, which increases in size, owing to the expansion of the water vapor when the sheet is subsequently annealed. During the annealing, however, the reaction is revealed, for at a red heat water vapour is again decomposed, with the formation of oxide and the liberation of hydrogen."

Prior to making any of the experiments which are to be described in the present paper, the author formed the view that there was another explanation which would fit in with all the facts quite as well as the one put forward by Law.

Whilst agreeing that isolated patches of oxide might give rise to blisters, it does not seem necessary to postulate that reduction of this oxide need take place. Indeed, to the author it seems just as conceivable that undissolved impurities, or constituents such as carbide of iron and manganese sulphide, might behave in precisely the same manner as oxide of iron in this respect. Taking the fact that hydrogen has the power of diffusing through iron, it may be assumed that this diffusion will naturally continue until the metal becomes saturated with the gas. The saturation limit will no doubt vary with the temperature and strength of acid used. With perfectly pure iron this diffusion and saturation of the metal is probably brought about by the hydrogen atoms being, so to speak, passed from one atom of iron to another, until the former is uniformly distributed through the metal. Commercial steels cannot, however, be perfectly homogenerous in this sense, and some are less so than others. If it be assumed that small dots represent atoms of iron, and an area X is an inclusion of some kind which is not iron, then, during pickling, the hydrogen atoms would enter at the surfaces, and would be conveyed along the path of the iron atoms until they reached the boundary of X. At this stage further diffusion would be obstructed by the inclusion, and the hydrogen atoms reaching this surface would be forced to detach themselves from those of iron by the continuous flow of hydrogen from behind. As these hydrogen atoms become detached they would form molecules H_2, which of course are incapable of diffusing through iron at ordinary temperatures. Hence molecular hydrogen would accumulate at the boundary of X, and the amount of this entrapped gas would go on increasing, because the inflow would continue so long as pickling was in progress; the rate of inflow being scarcely, if at all, affected by the increasing internal pressure. Naturally, the thinner the plate, or the nearer the inclusion to the surface, the shorter will be the time required for the hydrogen to penetrate to such inclusions. In very thin plates the internal pressure at these inclusions will quickly become so great as to cause a blister by forcing out the surfaces of the sheet, even at ordinary temperatures, or at something below 100 deg. C. But, even if the pressures be not high enough to do this by the end of the pickling operation, there is a further opportunity during white annealing, or when the sheets are being passed through the tinning bath. This is a very simple explanation; but it must be confessed that it would be more acceptable if experimental facts could be obtained that would carry it a little beyond the stage of pure speculation. It was a difficult matter to see how this could be done by planning experiments that would be conclusive, or even definitely helpful. The most difficult thing to arrange in this respect was, to have an inclusion in a known position without cutting the specimen to find it. After much consideration, and many attempts of different kinds, a very simple and satisfactory test, so far as oxide of iron is concerned, was devised.

To make this clear, it will be useful briefly to draw attention to a few facts relating to the manufacture of tin-plates. In rolling, after the original bar has been hot-rolled in the sheet-mill for a number of passes, the sheet is doubled, reheated, and the doubled sheet again hot-rolled. This operation of doubling, etc., is repeated until the thickness of the sheet has been reduced to the desired degee. As these rolling operations are carried out at a good red heat, each sheet in the finished bundle is separated from its neighbors by a film of oxide of iron. The success of subsequently opening, that is, separation of these sheets from one another, after shearing the folded edges, depends almost entirely on whether the film of oxide between the sheets has remained continuous or not. If the film has become broken during rolling, welding at such points might occur, and complete separation becomes difficult, if not impossible.

It will thus be seen that by taking two sheets of this kind, which have not been disturbed since hot-rolling, it ought to be possible to get an oxide inclusion, in a known position, and study the effect of pickling upon it. With this in view, a large number of compound sheets have been examined. For this purpose circular discs, 3 inches in diameter, were cut out and the edges carefully welded together by means of an oxy-hydrogen flame, thus sealing up the two plates and obtaining an inclusion of oxide of iron. The thickness of the discs was 0.46 millimeter—that is, each sheet was 0.23 millimeter thick minus half the thickness of the oxide film.

On immersing these specimens in aqueous solutions of sulphuric or hydrochloric acid of any strength up to 30 per cent, acidity, and at any temperature between 0 deg. and 100 deg. C., it was found that hydrogen penetrated to the oxide layer and accumulated between the sheets. The pressures of the gas were sufficient to cause a complete separation of the sheets at all points except at the edges, where they had been welded together. The degree of bulging could be made to be as much as ¼ in., but this of course was determined by the length of time the discs were kept in the acid, and by the rate of acid attack; the latter increasing with the acidity and the temperature. At temperatures approaching 100 deg. C. complete separation of the sheets occurred in the course of a few minutes, but at low temperatures much longer times were required. It may be interesting to note that since this separation of the sheets could be brought about at 0 deg. C., when there could be no possibility of the formation of steam or any material quantity of water vapor, Law's explanation does not seem to be tenable.

Purely qualitative experiments were made to ascertain whether the diffusion of hydrogen could be prevented, and pickling, that is, the cleaning of the surface of the sheet, still effected. By making one of the above-mentioned discs the anode, and any other metal the cathode, using dilute sulphuric acid as the electrolyte, and passing a current of a few amperes through the solution, it was found possible to completely disslove these discs without showing signs of hydrogen diffusion at any stage.

Another experiment was made by taking a strip of one of these compound sheets and rolling it down to a very thin gauge, with intermittent annealing. One-half of this was then pickled in the usual manner, but at ordinary temperatures, and the other half was electrolytically pickled.

Attempts were made to replace the oxide film by one of carbide of iron, but, so far, these have not been successful. It is, therefore, impossible to say with any degree of finality that this constituent, or manganese sulphide, will, or will not, behave like oxide inclusions, but the author is very much inclined to believe it will. In this connection it is of interest to note that by covering a perfectly clean plate with a film of collodion, on one side only, and immersing the sheet in dilute sulphuric acid, blisters are produced under the collodion. These do not persist for long, however, presumably because the hydrogen diffuses through the collodion. Another interesting demonstration of a similar kind was obtained by taking an enamelled dish from which some of the enamel had been removed from the inside; after allowing cold dilute sulphuric acid to rest in this dish for some time, it was found that considerable quantities of the enamel became flaked off the outside surface. In this instance it was found that the pattern obtained by the flaking off of the enamel corresponded with that of the acid attack on the inside of the dish.

Quantitative Measurements.

After having reached this stage in the investigation the author thought it would prove useful, as a further step in the study of pickling, and certainly interesting from a purely theoretical point of view, to make a careful examination of the conditions which govern the rate of hydrogen diffusion through steel. Quantitative evidence in this direction seems essential before going further with the more important aspects of the practical problem, such as endeavoring to devise a commercial method of preventing, or even regulating, the degree of hydrogen diffusion into steel during pickling. Many different kinds of apparatus were made, and tried, before any real success was achieved. In view of the possibility of a large number of tests being required, it was considered desirable to use the simplest form of apparatus consistent with a reasonable degree of accuracy.

An apparatus consisting of a stout glass cylinder with a carefully ground flange at the bottom, and a strong glass saucer shaped dish also flanged with ground surface to face upon the cylinder flange. Into the base of the saucer is fused a length of strong glass capillary tubing, bent as shown in the illustration. A perfect gas-tight fit was obtained by the use of two thick rubber washers well smeared with vaseline, and four strong metal clamps, onl ytwo of which are shown

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in the sketch. All air in the space below the experimetal sheet was carefully excluded before each test was made, by pouring mercury through the glass capillary. This was done after the sheet was in position, but before the clamps were screwed down, the last trace of air being removed by tilting the apparatus whilst a good stream of mercury was flowing between the sheet and the lower rubber washer. The pressure of mercury causing this flow was maintained whilst the clamps were being screwed down as far as they would go. This apparatus rested in a retort stand and could be immersed in a bucket of water; under these conditions it was possible to conduct experiments at a desired constant temperature anywhere between 0 deg. and 100 deg. C. Before starting an experiment sufficient time was allowed for the apparatus to reach the desired temperature, the measured quantity of acid being separately heated to the same temperature. The acid was poured into the glass cylinder A, and was thus brought into contact with the upper surface of the sheet, with the generation of hydrogen. Any hydrogen which diffused through the metal displaced a corresponding volume of mercury, forcing it out of the capillary tubing at F, where it could be collected nad weighed at convenient intervals of time. By weighing the mercury more accurate determinations of the volume of hydrogen diffused were obtained than could have been attained by any convenient method of measuring the volume directly.

The circular portion of the sheet which was in contact with the acid was 2.5 inches in diameter, corresponding with an area of 31.67 centimeters.

During the earlier experiments that were made it became evident that, although the apparatus was capable of giving the required degree of accuracy, there was a possible disturbing factor in the specimens themselves which must be kept constant if comparative results were to be obtained. For example, it was noticed that different results were obtained if the surface of the sheet in contact with the acid had, or had not, a coating of oxide upon it. This was the case even when every care was taken to keep all other disturbing factors constant. In view of this, special care was taken in selecting sheets to see that all had, as nearly as could be estimated from a visual examination, about the same amount of oxide of iron upon them. To still further guard against irregularities arising from this cause, each complete set of tests was made with samples that were cut from the same sheet, and care was taken to ensure that the acid attack was always on the same side of the specimen in relation to the original sheet from which they were cut.

All experiments have been made with hot-rolled sheets, or in the case of thick specimens, with samples that had been heated to and cooled from 900 deg. C. In all cases, unless otherwise stated, the volume of solution employed was 100 cubic centimeters.

Effect of Varying H_2SO_4 Acidity on the Rate of Hydrogen Diffusion.

Hot-Rolled Sheets 0.005 Inch Thick. — In this series of experiments a wide range of solutions of sulphuric acid in water was used. The temperature was the same in each case, namely, 18 deg. C. The results are given in Tables I to VIII. The volumes of hydrogen diffused have been corrected for 0 deg. C.

From the nature of the subject under consideration, it will be readily understood that the results could be examined from two different points of view. (a) It would be possible to estimate the volume of hydrogen diffused during a period of time which could be kept the same in each case, or (b) determine the time required for the diffusion of a constant volume of hydrogen. So far as the author can see, neither method possesses any definite advantage over the other. In both there would be a factor which changes with variations in the strength of acid, namely, the amount of iron dissolved. For the purpose of the present investigation it was decided to estimate the times required for the diffusion of 4 cubic centimeters of hydrogen. These times were obtained after plotting the results which are given in the tables, and reading off the values corresponding with the above-mentioned volume. These values have been plotted graphically against the respective acidities of the solutions used (see Fig. 10, p. 15). From this curve it will be observed that the rate of diffusion rapidly increases as the acidity is raised from about 5 per cent to 15 per cent, and very slowly as the acidity is further increased.

TABLE I

4.9 Grammes H_2SO_4 per Litre. Temperature, 18° C.

Duration of Test		Volume of Hydrogen, at 0° C., Diffused
Hours	Minutes	C.c.
1	25	0.129
3	25	1.060
17	55	15.350

Estimated time for the diffusion of 4 cubic centimeters of hydrogen, 8 hours

TABLE II

9.8 Grammes H_2SO_4 per Litre. Temperature, 18° C.

Duration of Test		Volume of Hydrogen, at 0° C., Diffused
Hours	Minutes	C.c.
2	20	0.63
4	20	2.10
5	5	2.71
6	15	3.70
12	20	10.69

Estimated time for the diffusion of 4 cubic centimeters of hydrogen, 6 hours 36 minutes

TABLE III

37.0 Grammes H_2SO_4 per Litre. Temperature, 18° C.

Duration of Test		Volume of Hydrogen, at 0° C., Diffused
Hours	Minutes	C.c.
1	0	0.43
2	0	1.39
3	0	3.05
4	8	5.28
5	0	7.28
6	0	9.62
7	0	12.11

Estimated time for the diffusion of 4 cubic centimeters of hydrogen, 3 hours 30 minutes

TABLE IIIa

108 Grammes H_2SO_4 per Litre. Temperature, 18° C.

Duration of Test		Volume of Hydrogen, at 0° C., Diffused
Hours	Minutes	C.c.
1	30	2.02
2	45	5.52
3	22	7.78
3	45	9.04
4	20	12.05

Estimated time for the diffusion of 4 cubic centimeters of hydrogen, 2 hours 12 minutes

TABLE IV

184 Grammes H_2SO_4 per Litre. Temperature, 18° C.

Duration of Test		Volume of Hydrogen, at 0° C., Diffused
Hours	Minutes	C.c.
2	0	4.47
3	0	9.52
3	30	12.47

Estimated time for the diffusion of 4 cubic centimeters of hydrogen, 1 hour 48 minutes

TABLE V

282 Grammes H_2SO_4 per Litre. Temperature, 18° C.

Duration of Test		Volume of Hydrogen, at 0° C., Diffused
Hours	Minutes	C.c.
1	0	1.57
2	0	6.18
2	30	9.39
3	0	13.57

Estimated time for the diffusion of 4 cubic centimeters of hydrogen, 1 hour 30 minutes

TABLE VI

381 Grammes H_2SO_4 per Litre. Temperature, 18° C.

Duration of Test		Volume of Hydrogen, at 0° C., Diffused
Hours	Minutes	C.c.
1	0	1.81
1	30	4.41
2	0	7.41
2	30	11.35
2	40	12.66

Estimated time for the diffusion of 4 cubic centimeters of hydrogen, 1 hour 24 minutes

TABLE VII

571.5 Grammes H_2SO_4 per Litre. Temperature, 18° C.

Duration of Test		Volume of Hydrogen, at 0° C., Diffused
Hours	Minutes	C.c.
1	30	5.89
1	47	7.93
2	5	10.19
2	20	12.19

Estimated time for the diffusion of 4 cubic centimeters of hydrogen, 1 hour 6 minutes

TABLE VIII

762 Grammes H_2SO_4 per Litre

In this case there were 2.75 cubic centimeters of hydrogen diffused at the end of 1 hour 15 minutes, but the rate of acid attack had sensibly decreased before that time, and afterwards ceased altogether.

There was no perceptible action with another test in which 950 grammes of sulphuric acid was present per litre.

(To be continued)

Henry Irwin, Jr., Dies at Shields, Pa.

Henry Irwin, aged 72, treasurer of the Shenango Furnace Co., and for many years one of the most prominent figures in the steel business, died in his home, Maple lane, Shields, Pa., recently, after a short illness.

Mr. Irwin was born in Irwin avenue, Allegheny, August 10, 1852, the son of Henry and Elizabeth Peterson Irwin. He was educated at Prof. Wakeham's school and at the Western University of Pennsylvania. After leaving school Mr. Irwin became engaged in the coal and brokerage business and about 35 years ago became associated with the late William P. Snyder in the pig iron and steel business, being identified for many years with W. P. Snyder & Co. When the Shenango Furnace Company was formed Mr. Irwin was elected treasurer, a position he held until his death. Mr. Irwin was also treasurer and director of the Shenango Steamship Company, and of the Shenango Steamship and Transportation Company.

He was a charter member of Doric Lodge No. 630, F. and A. M., of Sewickley. Mr. Irwin was married to Miss Lillie L. Irwin, of Pittsburgh. Besides his widow he is survived by one son, Charles Edwin Irwin, and two sisters, Mrs. Henry Holdership, of Montclair, N. J., and Mrs. D. M. Rankin, of Sewickley. Funeral services will be held at the late home Sunday at 2:30 p. m.

Ralph C. Richards, Fifth President of the Prominent Safety Worker Dies

Ralph C. Richards, one of the organizers and fifth president of the National Safety Council, died at his home in Geneva, Ill., January 3, after a long illness. Mr. Richards was 69 years old and had retired from his position as claim agent of the Chicago & North Western Railroad with which he had been associated for 54 years, July 1, 1924.

Mr. Richards' life is significant for the illustrous part he played in the inception and development of the safety movement. He began work with the railroad at the age of 15 as an errand boy in the claims department. He studied law evenings, was admitted to the Illinois Bar and rapidly advanced to positions as assistant general solicitor, general solicitor and, fianally, claim agent. In the latter position he was constantly associated with the misery connected with accidents which, at the time, were commonly believed by both the workers and the management to be unavoidable.

In 1910, Mr. Richards, endowed with a strong personality and with the belief that the human element had much to do with accidents, established organized safety work on the North Western. In the first year of his efforts, 792 of the workers of the railroad were appointed safety committeemen and met with the management to discuss the causes and remedies for accidents. There was a notable reduction in fatalities and injuries both to employees and the passengers as a result of the work done by this committee under Mr. Richards' leadership that first year. That accidents could be reduced if both the employer and the employee worked together for results was clearly demonstrated.

Mr. Richards attended the first co-operative safety congress in Milwaukee in 1912 and was selected a member of the committee of 25, charged with the responsibility of considering a second safety congress and the possibility of organizing a National Safety Council. A committee of 25 selected five of their number to draft the constitution and by-laws and Mr. Richards was one of these five. He was one of the first members of the National executive committee; he was the first chairman of the steam railroad section and he occupied virtually every important office in the National Safety Council including the presidency in 1919 to 1920.

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CURRENT REVIEW

Some Developments in the Electrical Industry During 1924

Many of the Applications Are of Direct Interest to the Steel Industry.

By JOHN LISTON*

THE aggregate kilowatt capacity of steam turbines completed and under construction at the close of the year exceeded all previous records. Among the large units completed and placed in service was one rated at 60,000 kw., consisting of a high pressure and a low pressure unit, each driving individual generators.

The first 35,000 kw. single cylinder turbine, designed for 550 lb. steam pressure and 750 deg. F. total temperature, was placed in commercial service in the Philo Station of the American Gas and Electric Company.

Two machines for operation under conditions similar to the 60,000 kw. unit referred to above were under construction. These machines differ from the larger two cylinder machines in that they do not drive individual generators, but both cylinders are coupled to a single 40,000 kw. generator.

The first turbine designed for operation with a steam pressure of 1,000 lb., is under construction in the shops. The high operating pressure involved unusually heavy mechanical construction for the turbine casing.

Among the large high speed machines under construction are some rated at 50,000 kw., 62,500 kva., 1800 r.p.m. The production of machines of this capacity and speed has been rendered possible by the use of twisted conductors in the armature windings and improved methods of rotor construction. Other machines of exceptional capacity include 60,000 kw., 60,000 kva., 1500 r.p.m. units. All of these large machines when completed will represent maximum capacities for the speeds at which they operate.

The Emmet Mercury Turbine and Boiler installation made for the Hartford Electric Light Company, Hartford, Conn., attracted a great deal of attention and the success achieved during one year of operation was very gratifying to all concerned. Experience indicated that certain improvements in details can, to advantage, be made and the necessary changes are now being carried out. The Emmet turbine and boiler were described in the July issue of this magazine.

Industrial Motors.

A new line of single phase adjustable varying speed, brush shifting motors, was produced having a 2½ : 1 speed range with constant torque load. They are arranged for interchangeable 110 and 220 volt, and for hand or remote control.

The line of single phase repulsion induction motors, utilizing a squirrel cage rotor construction and eliminating centrifugal switch, was extended to include the odd frequency motors and the reversing type of motor. The reversing type is capable of reversal from full speed in one direction to full speed in the opposite direction, such as for hoist and crane service, but requires special control in the case of elevators.

Single phase motor development also included a line of varying speed repulsion motors designed primarily for direct connection to show speed exhaust fans. These motors are totally enclosed and have the series characteristics desirable for fan load.

A new line of synchronous motors for driving air and ammonia compressors employ a double bar squirrel cage winding which permits the designing engineers to have greater control of the current and torque during the starting period of the motor, and in addition permits the motor to be thrown on at full voltage with the assurance of minimum starting current and proper torques.

A high speed, drawn shell type of motor was produced, intended primarily for the operation of woodworking machines although they are well adapted for grinder and similar service. They consist of stator and rotor only, as they are intended to be "built in" on the driven machines.

Among the special motors was a group of 20 induction type units designed for operation in an atmosphere containing one-half of one per cent of acetone. All of these motors are of the enclosed ventilated type, taking air in from each end and discharging it through holes in the side of the stator frame.

Electric Welding.

A new type of d.c. arc welding generator was developed in which the adjustment of the welding current is obtained by shifting the brushes. This machine is rated 250 amperes, one hour, 50 deg. C.—200 amperes continuous, and is capable of handling a maximum welding current of 300 amperes.

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*General Electric Company, Schenectady, N. Y.

The use of automatic arc welders showed a consistent increase, and new types of machines were produced for use in manufacturing.

As an indication of the results which were obtained with automatic welding machines, one manufacturer utilized them for the construction of 550-gallon underground gasoline storage tanks made of galvanized iron, each tank having three longitudinal seams 116 inches long, the material being No. 12 gauge (7/64 inch stock).

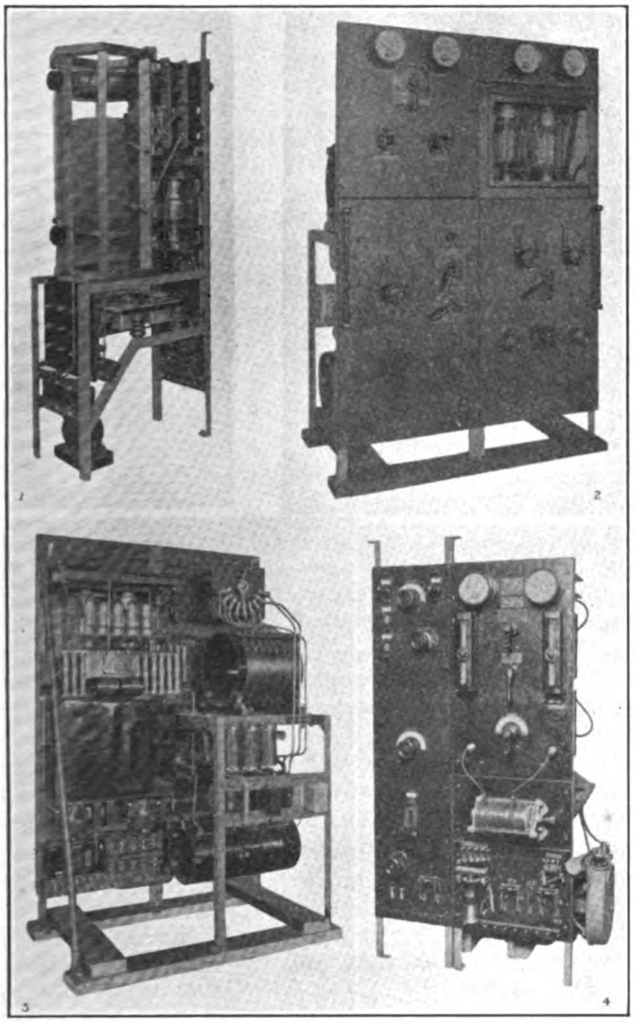


FIG. 1—*Vacuum tube transmitter attachment for use with spark transmitters.* FIG. 2—*2 KW transmitters for destroyer sets.* FIG. 3—*2KW transmitters for destroyer sets (rear).* FIG. 4—*Vacuum tube transmitter attachment for use with spark transmitters.*

In regular production, these seams were welded at an average rate of about 16½ inches per minute or a total of 7 minutes per seam. The welding current was 200-ampere with about an 18-volt arc. Previous methods of manufacturing these tanks took about 7½ hrs. per tank, whereas the automatic welding machine reduced this to about 5 hours. It is evident from this record that the arc welding of galvanized iron is entirely feasible provided suitable welding electrodes are used.

Radio.

Transmitters were designed and built for the U. S. Bureau of Lighthouses, for use as radio beacon stations. These units, sometimes referred to as "fog signal transmitters", are used in foggy weather to permit ships in the vicinity of the beacon station to take radio compass bearings, and to be warned of the proximity of the beacon station. In other words, a radio signal, in the form of one or two letters, constantly repeated, is utilized in place of the visual signal from a lighthouse.

For installation of ships, transmitters were produced which constitute the latest development in low power tube transmitter design. They have an output of two kw. in the antenna, and are built to transmit either continuous wave or sine wave modulated signals. They utilize a new power tube having an output of 1 kw. and operating on a plate potential of 2000 volts d.c.

The improvements in broadcasting equipment were centered on quality, increased output and pick-up devices. The quality of the output of the broadcasting transmitters was improved to a point where ultra-sensitive receiving equipment and loud speakers indicate that the transmitters are faithfully reproducing the studio material.

Extensive tests were made to establish the merits of transmission at frequencies differing widely from those now in general use for broadcasting. Most of this work was devoted to transmission at very high frequencies, up to 20,000,000 cycles.

The results of this work indicate that these frequencies hold some promise for radio relaying and for transmitting over great distances under certain conditions.

An electron tube relay equipment was produced by which the 200 kw. high frequency alternators may be satisfactorily controlled for telegraphy to a rate of 250 words per minute or about 10 times the normal average rate of sending.

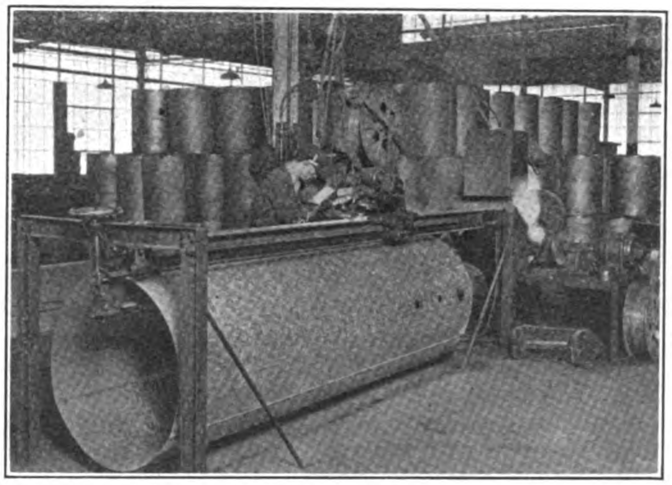


FIG. 5—*Welding longitudinal seam No. 12 gauge (7/64 in.) galvanized iron tanks using G.E. automatic arc welder and G.E. welding electrode in the shop of the Wayne Tank & Pump Company, Ft. Wayne, Ind.*

Two improved types of large antenna tuning coils, one for outdoor service, the other for indoor service, when used with large antennae should greatly increase the efficiency of large radiating systems.

W. D. Bearce, railway engineering department, reports, sales of equipment for the operation of electric railways and electrified steam railroads have show a steady improvement over last year and inquiries now on hand indicate a continuance of the trend towards rehabilitation including the purchase of modern equipment for both substations and rolling stock.

Self Propelled Cars and Locomotives.

Sixty-ton oil electric locomotive, which has been tried out extensively by a number of steam roads has received much favorable comment. This locomotive is equipped with an oil burning engine designed and built by the Ingersoll-Rand Company direct connected to a G. E. generator. Electric motors, control, etc., are also supplied by the General Electric Company, while the cab and trucks are built by the American Locomotive Company. The unit is designed to replace a steam engine in switching service and the control is arranged so that it may be manipulated much in the same manner as the ordinary steam locomotive. The electrical equipment is arranged to operate automatically and the design is such that ample protection is provided against overload.

Another similar development along this line which has received much attention is a gas electric locomotive weighing 40 tons built for the Pittsfield Works of the General Electric Company. This unit is equipped with a Sterling-Dolphin gasoline engine direct connected to a 100 kw. electric generator. The control is similar to that on the oil electric locomotive.

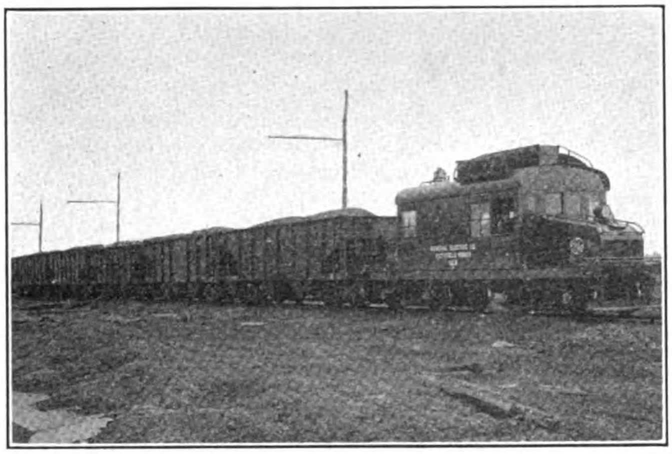


FIG. 6—40-*ton gas-electic locomotive class* 404-*G*-80-4*HM*-830*B*-500 *volts.*

Interest has revived in the gas electric car along the lines of the equipments built during the last 10 years by the General Electric Company. This car is being developed by the Electromotive Engineering Company, using a 15 hp. Winton gasoline engine, 110 kw. G. E. generator, motors and control furnished by the General Electric Company, and a carbody and trucks built by the St. Louis Car Company.

Steam Railroad Electrification.

Renewed activity in railroad electrification is indicated by orders for new equipment from four different roads.

The most important of these projects is the Chicago Terminal Electrification of the Illinois Central Railroad, which decided to electrify its suburban passenger service using 1500 volts d.c. over a year ago. The contracts awarded for multiple unit cars and equipment include an order to the General Electric Company for 120 complete control equipments for the motor cars, 120 auxiliary control equipments for trail cars, and motors for 60 cars.

Another important conversion is being put through by the Staten Island Rapid Transit Company and the Staten Island Railway subsidiaries of the Baltimore & Ohio Railroad on the lines running from St. George, Staten Island, to Tottenville and South Beach. A total of 17 miles of route is involved, all double track. Equipment now on order includes 80 steel passenger cars to be equipped with two G. E.-282-200 hp., 600 volt motors and type P.C. control.

Another order for electrification equipment has been placed by the New York, New Haven & Hartford Railroad Company with the General Electric Company for five freight locomotives and two switching locomotives of an unusual design. Each of the locomotives will carry a transformer and synchronous motor generator set stepping down the current from the 11,000 volt trolley to d.c. for operating the d.c. motors.

As a part of its program for the electrification of the west side freight lines, the New York Central Ralroad has placed orders with the General Electric Company for seven 100-ton switches and two 170-ton freight locomotives to handle freight traffic in New York City. These locomotves will be of the standard geared design using 600-volt motors.

Orders were placed during the year by the Japanese Imperial Government for four 66-ton, 1500-volt freight locomotives to be used in connection with extension of present electric lines. These are similar in design to two units furnished last year.

The Mexican Railway Company, Ltd., has begun operation of its electric zone between Mexico City and Vera Cruz, and this electrification continues to hold the interest of railroad engineers throughout the country. Ten 150-ton, 3,000-volt locomotives were delivered during the year and the substation was placed in operation shortly after the locomotives arrived.

Reports from Spain indicate very successful operation of the 3,000-volt electrification of the Spanish Northern Railway over the Pajares gradient. The equipment now operating in this service includes six 90-ton freight locomotives and two complete 3,000 kw. substations.

City and Suburban Railways.

The New York Subway and Elevated lines were the principal purchasers of equipment durng the past year for metropolitan rapid transit.

283 YEARS LATER BOSTON BUILDS A BLAST FURNACE

E. F. Bayrer, of the engineering department, returned from his vacation in the east some weeks ago bringing with him an interesting article on "New England, the Birthplace of the Steel Industry." The article appeared in the program of the Boston Convention of the American Society for Steel Treating and was written by Hal Chase. Believing that many of the readers of this publication would find something of interest in it, a part of the article is here reprinted.

The first iron mined and smelted in the United States was taken from the bogs of Massachusetts; this was in 1642, one hundred and thirty-four years prior to the signing of the Declaration of Independence. The Saugus Iron Works, erected that year, was the first building erected in America for the smelting and working of iron, and the ore from which the metal was obtained was mined on the bog meadows of the Saugus River. This plant continued in operation for 46 years. It was here that the dies for the Pine Tree Shilling, the first coinage in the country, and the only coinage prior to the War of the Revolution, were made, and the first patent granted on this continent was granted to the first superintendent of this foundry, in 1646. This patent was granted on a water wheel, which device was to form the controlling factor in the sole source of power for many years to come. This same foundry superintendent, Mr. Joseph Jenckes, was the inventor of the first American scythe, a great improvement on the scythe then in use in Europe. This model scythe is still in use today, as the most practical ever manufactured.

The metal working industry in Massachusetts grew very rapidly, and plants were erected in rapid succession in Bridgewater, Braintree, Concord, Lancaster, Topsfield, Ipswich, Taunton and Boxford. The ore from which the metal was obtained was all native-mined Massachusetts ore. The early history of Taunton indicates that iron ore of the bog and pond variety was mined there steadily from the year 1670 and continuing until 1720. The Chartley Iron Works, erected in Taunton, were notable for the fact that the iron work and tools required for the maintenance and erection of that plant were manufactured at the Taunton iron works from native New England iron in 1674. Massachusetts continued as the chief producer and manufacturer of iron for 100 years after her settlement in 1620.

—Gary Work Circle.

1925—ANOTHER FIVE BILLION DOLLAR BUILDING YEAR

Perhaps the most interesting statistical development in the building field during the past few years has been the Annual Building Survey and Forecast by the Architectural Forum. For the past three years, since the institution of this annual forecast, the Forum prediction as made the first of each year, has been within 3 per cent correct when compared with actual figures at the end of the year. This forecast of building activity is based on a comprehensive survey carried out through individual reports from a large number of architects and from building contractors, bankers and others directly interested in the construction field. The investigation ism ade in 19 building types and covers each state. Percentage comparisons are made with the previous year in each classification, so that there is provided not only a definite measure of activity in each district, but a relative measure of the increase or decrease of public interest in the particular building type in question.

The accompanying tabulation represents in detail the Fourth Annual Survey and Forecast of the Architectural Forum, which indicates for 1925 another $5,000,000,000 building year, the actual figure determined by the survey being $4,992,318,000.

This survey was conducted in exactly the same manner as that used successfully for the past three years during which period the forecast of the Architectural Forum presented at the first of each year, has closely approximated the actual totals of the year. In January, 1924, the published forecast of the Architectural Forum predicted an expenditure of $5,560,367,700 during that year. Figures now available prove that this prediction was correct within 3 per cent. A recent statement by S. W. Straus & Company is as follows:

"The year 1924 has been the largest building year in the history of the country in point of financial requirements. Last year the volume was $5,500,000,000, but aggragate operations this year exceed the 1923 total by about 4½ per cent.

A recent statment by the F. W. Dodge Corporation is as follows:

"1924 was another record-breaking building year. Total contracts awarded during the year in the 36 eastern states (which include about ⅞ of the total construction volume of the country) amounted to $4,481,807,000, indicating that the total volume for the entire country was well over $5,000,000,000."

Thus, reports from dependable sources indicate that the Forum Forecast for 1924 was correct and the statement made last January that "there will be a late reaction in the fall of 1924, providing during the year two peaks of building activity totalling more than $5,000,000,000 for the year" has been changed from a forecast to a fact.

Factors Influencing 1925 Building.

All evidence would seem to bear out this prediction that 1925 is to be another record building year and that the great momentum of the building industry would continue almost unchecked. The basic elements which establish the total volume of building in any given year include the following:

An established shortage of buildings.
Public confidence in the building situation.
Stabilized costs.
Good transportation conditions.
Ample mortgage money.
Good labor conditions.
Well maintained rentals.
Sound general business conditions.

In regard to the existing building shortage, a survey recently conducted by S. W. Straus & Company states as follows:

"The year 1924 closes with a building shortage of considerable magnitude confronting the industry. In the cities of more than 10,000 population alone, this shortage is in excess of $4,000,000,000 with a very large apparent shortage in places of less than 10,000 population."

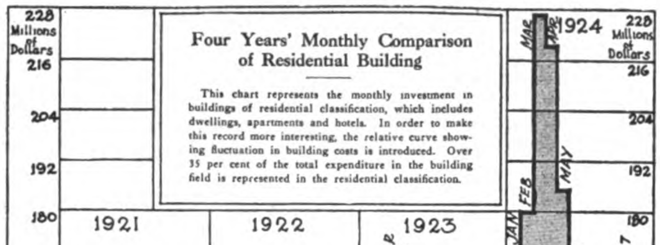
Speaking of general business conditions and of the building situation, Secretary Hoover, in a recent statement on the economic prospects for the year 1925, says in part:

"The construction work of the country has maintained high activity. While the shortage, particularly of housing and business buildings, due to the cassation of construction during the war, has been to a large degree overcome, yet continued high real wages and general prosperity create a demand in excess of that due only to increasing population, because of the insistence of a population of rising standards of living, for more elbow room and better housing generally. One striking factor in maintenance of increased construction activities is the effect which the automobile is producing in increasing the demand for road construction and in causing migration of population in many of our towns to new housing in the suburbs.

Another effect of these forces is to maintain rents out of line above the general price levels. With our high real wages and little unemployment, there is no reason to expect any material change in the course of this industry.

"The annual survey of the Department of Commerce shows that the New Year begins with the economic structure of the world upon more solid foundations than at any time since the war. With the exception of a few spots of secondary importance, there has been during the past year a real advance toward social, economic, and political stability throughout the world. The only exceptions are Russia and China, which even before the war contributed less than 3½ per cent of international commerce and of course a part of this continues. Generally the world is producing more good, there is fuller employment, there are higher standards of loving, more assurance of economic stability for the future and more promise of peace than we have seen for many years. The world is by no means free from liability to economic shock, yet the forces today in motion all tend to great promise for the forthcoming year.

ARCHITECTURAL FORUM



Four Years' Monthly Comparison of Residential Building

This chart represents the monthly investment in buildings of residential classification, which includes dwellings, apartments and hotels. In order to make this record more interesting, the relative curve showing fluctuation in building costs is introduced. Over 35 per cent of the total expenditure in the building field is represented in the residential classification.

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"Savings continue at a very high rate, as indicated by the increasing savings deposits, the large absorption of bond issues, and the extraordinary expansion in insurance, thus demonstrating that there has been maintained a high state of efficiency throughout industry and commerce, with little evidence of waste, extravagance and speculation. In fact, the most far-reaching movement in our economic life today is the larger understanding of its broad problems, the better appreciation of the factors of stability, and the definite progress in the elimination of waste, through more stable employment, through better administrative methods and through the rapid march of scientific discovery. That we are able to maintain wages at 100 per cent above pre-war while the cost of living is 72 per cent, and the average wholesale price of commodities about 50 per cent above pre-war, is the very definite proof of increasing efficiency in production and distribution and of the free flow of competitive action."

The industrial building field during the last three years has shown a decided recovery from the slow period immediately following the war, and 1924 has contributed a quota equal to that of 1922 or 1923.

The facts and figures as presented by the Architectural Forum promise for 1925 a sound and prosperous year in the construction industry, with probably more general activity throughout the country and less concentration of record-breaking activity in the New York district. Again, there will be two peaks of building activity, one occurring in the normal spring building season, and another in the late fall, totaling in all an expenditure of nearly $5,000,000,000 for building materials and labor.

Technical Articles

"Greater Output by Plant Rearrangement"—Alloy Steel Units Moved into New Combinations—Considerable Equipment Added—New Boiler House.

"Storing Coal in Hollow-Tile Silo" — Handling Equipment with Self-Weighing and Recording Features—Live and Reserve Storage in One Unit.

"Steels Used by American Railroads"—Modern Locomotives and the Steel in Them—Steel Rails of Today—Three Authorative Addresses Before Steel Treaters.

"American Coke Output Analyzed"—Furnace and Non-Furnace Ovens—Coke Used in Making Pig Iron By-Product and Beehive Compared.

"Fundamentalism in Ferrous Metallurgy."

"New Centrifugal Cast Iron Pipe Process."

"Strong Aluminum Alloys."

"Where Steel Went in Nineteen Twenty-Four."

"Steel Capacity in the United States."

"Map Locating Steel Plants in United States."

"Will the Future Airplane Be of Metal?"

"Former German Dock Lifts Former German Ships."

"What 1925 Has in Store."

"Everything Gets Back to the Ingot."

"First Units of Gary Tube Company."

"Preparing for Active Year on Ore Ranges."

"Ore Shipments Not Equal to Tonnage Used."

"The Trend in Metallurgy Last Year."

"The Ferroalloy Industry in 1924."

"New Capacity in Iron and Steel Plants."

"Inspection Standards for Steel Castings"—Some of Those Laid Down by Electric Steel Foundries, Based on Research—Meeting Specialization in Purchase Requirements.

"Basic Production on 1919 Level" — November Shows a Drop after Successive Increases since July—All Figures are Lower than Last Spring.

"Cost Trends in Manufacturing"—Labor and Fuel in Iron and Steel—Machine Tools—Tendencies Summarized Indicate Low Labor Cost.

"More By-Product Coke Plants for Iron Industry."

"Details of New Scrap Specifications."

"Continuous Molding and Casting"—What Conveying Machinery Can Accomplish Shown in Plant of Warren Foundry Company at Warren, Ohio.

"Getting Castings out on Schedule"—Planning and Controlling Production in Plants of All Sizes Aids in Determining Costs — Improving Production Inspection.

"Research Method for Blast Furnaces" — Use of Symbols to Designate Observed Conditions Facilitate Work—Records Capable of Later Intimate Analysis.

"Engineering of Material Handling"—Machinery Installations for Putting Goods Into and Out of Storage or Cars or Ships Differentiated from Those for High-Speed Production.

"Tremendous Saving by Standardization."

"Sheet Steel Simplification."

"Properties of Metals at Extreme Temperatures."

"Problems Solved in Machining Large Gears" — Turbine Speed—Reduction Units of Unusual Size Made at Philadelphia Navy Yard—Method of Cutting Teeth and Checking Accuracy.

"Would Check Waste by Preventing Booms."

—Iron Age during December and January.

Influence of Boilers Heated by Exhaust Gases on Output of Gas Engines*

As the result of a series of trials of a plant at the works of the John Cockerill Company, in which the exhaust gases from a double tandem internal-combustion engine of 5600 kw. (7500 hp.), using blast furnace gas, were led through the smoke tubes of a steam boiler, from which steam at 12 kilogs. per sq. cm. (170 lb. per sq. in.) was obtained and superheated to 158 deg. C. (316 deg. F.), the author found that 7195 kilogs. (15,862 lb.) of steam was generated per hour. Even if the engine was developing only 200 kw. (268 hp.) the evaporation did not fall below 6517 kilogs. (14,367 lb.) per hour, i. e., a drop of 96 per cent in the load reduced the rate of evaporation by only 11 per cent. The motor is as economical as a good turbine, and the steam produced can be employed to drive a turbine (when the total power is increased 21.5 per cent at full load, 41.5 per cent at half load, or 79 per cent at quarter load); or it can be used for other than power purposes. The author demonstrates that for a given power the addition of a boiler in this manner results in a very large saving in annual cost. A chart shows plant efficiency, heat consumption, etc., at different fractions of full load, and some of the results are tabulated. An incidental advantage is that it is possible to arrange that the gas pressure in the mains leading to the various gas motors is maintained practically constant, notwithstanding variations in its volume. This can be effected by utilizing steam to compensate for variations in gas engine power. This is a condition which minimizes waste and is obtained without detriment to efficient use of gas.—G. Deladrierre ("Rev. Un. Min. Met.")

Hides of 795 Steers Used for Belting Order

It was necessary to use the hides of 975 steers in making the leather belts required for the new Long-Bell Lumber Mill at Longview, Washington. Reduced to units of 1 in. single ply belting this order called for 94,436 ft. or nearly 20 miles of belting.

The packer steer hides for this order were purchased from the packers and then put through the Graton & Knight tannery at Worcester, Mass. This is the largest leather belting tannery in the world with a capacity of 300,000 hides yearly.

Belting manufacturers agree that lumber mills are extremely hard on belting. Only the highest quality, best made leather belts can stand up under the terrific wear and tear of the large, heavy duty lumber machines.

For this reason the hides used in building this belt equipment had to be selected from strong, healthy steers killed during the summer months when the hide is in its best condition.

Homestead Steel Executive Is Dead

Richard Moon, aged 60, superintendent of the mechanical department of the Homestead Steel Works, died suddenly in his home, 300 East Eleventh Avenue, Homestead. Death was attributed to heart disease.

He was born in Glasgow, Scotland, and came to Pittsburgh 36 years ago, during which time he had been identified with the steel works. He was an elder of the United Presbyterian Church, Homestead, and a member of Homestead Lodge No. 582, Free and Accepted Masons; Homestead Chapter No. 306, Free and Accepted Masons; Homestead Lodge No. 991, Independent Order of Odd Fellows; Knights of Pythias; No. 1 Commandery, Knights Templar, Pittsburgh; Consistory, Syria Temple, Pittsburgh; South Hills Country Club and Pittsburgh Field Club. He leaves two sons, John and Richard Moon, Jr.; two daughters, Mrs. Harry Rowell and Mrs. John Richards, and a brother, Ralph Moon of Motherwell, Scotland.

The Okonite Company will open an office at 310 South Michigan Avenue, Chicago, on February 1 and will take over the sale of Okonite products in the western territory. Charles E. Brown, formerly vice president of the Central Electric Company, has been appointed vice president in charge of the territory west of Pittsburgh and east of the Rocky Mountains of the Okonite Company, with headquarters in Chicago. A. L. McNeill, formerly manager of the railroad department of the Central Electric Company, has been appointed manager of the railroad department. E. H. McNeill, formerly railroad sales representative of the Central Electric Company, has been appointed sales engineer. Ray N. Baker, formerly railroad sales representative of the Central Electric Company, has been appointed sales engineer, L. R. Mann, formerly sales representative of the Central Electric Company, with headquarters at St. Louis, has been appointed manager of the St. Louis office.

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*Inst. C. E. Foreign Abstracts.

Gas Producer Theory and Practice

A Combination of Both Phases of the Producer Problem Into Proper Working Proportions.

By A. B. HUYCK*

PART II

WE are now brought to the intensely practical part of our problem, that being mainly ways and means for keeping our gas temperatures as low as possible.

Agencies Effecting Gas Temperature.

The temperature of the gas is effected by two things. The amount of steam in the blast by controlling the firebed temperature effects the gas temperature. So far as the gas man is concerned, however, this is not the controlling factor since the proportion of steam is generally fixed by the setting of the air slides in a certain position.

The gas temperature is controlled by the thickness of the coal layer carried on top of the fire. The gas coming up from the fire is cooled by the green coal, the amount of cooling depending on the thickness of the layer. With a uniform six-inch layer of good coal a gas temperature of around 1400 deg. F. can be expected. With a 20-inch layer the gas temperature may be cut down to 1,000 or 1,100 deg. F. With little or no green coal on the fire the temperature may run up as high as 2,000 deg. F.

Appearance of Gas.

The gas man operates his producer by watching the appearance of his fire and especially the appearance of the gas as it issues from a poke hole.

Gas at a temperature of 1,000 deg. F. is of a thick yellow appearance, shows no light over the poke hole and comes from a thick fire with a heavy coal layer on the top.

Gas at 1400 deg. is of a yellowish blue appearance with a thin cone of light over the poke hole and comes from a fire of fair thickness with perhaps six inches of coal.

Gas at 1800 deg. is of a grayish black appearance with a bright cone of light over the poke hole and comes from a thin fire with practically no green coal on the top.

The colors grade into each other as the temperature varies starting at lemon yellow at 1000 deg. going through blue, brown, gray and to black at 1800 to 2000 deg.

The quality of the coal has considerable to do with the appearance of the gas but in general the foregoing holds.

It must be admitted that the gas temperature and appearance are not infallible as a guide to the gas quality. Poor coal distribution or a fire which is cold in the bottom may result in a good appearing gas which is not of good quality but it is the most convenient way we have of judging how our producer is working and is a satisfactory way under ordinary operating conditions, if we know the characteristics of our coal and our producer.

The elements in the gas which can be seen are soot, tar vapors or heavy hydrocarbons. The main constituents of producer gas are invisible and that is the reason we may be mislead by the appearance of the gas.

Appearance of Firebed.

The fire-bed conditions can be seen from a poke hole to a certain extent. If the coal feed is cut off for a period the gas space over the fire "clears up" and any hole or fissure in the fire can be seen clearly. It is sometimes advisable to do this in order to see the location of a bad hole. Flame seen in the producer is a sure indication of a hole or crack. Bright spots in an otherwise cold top layer are indications of holes formed or forming.

In a producer operated with an exceedingly thin fire the gas space and top of the fire bed will be so hot that it is simply a glare and no idea can be gotten as to the condition of the bed. Indeed no idea is necessary because there can be no holes in such a fire. It is all hole and not more than an inch or so in thickness. It is not being operated as a gas producer but more like a furnace generating the heat in the producer and transporting it to the place where it is to be used, through the mains. Such operation is an abomination and means flagrant waste of fuel. Sad to relate there are many producers so operated.

Conditions Limiting Low Gas Temperatures.

In keeping our gas temperatures as low as possible we are of course limited by certain conditions. As has been stated with a good mechanical producer it is a relatively simple matter to get good practice. The quality of the coal has something to do with it although not as much as with the older types of producers. With a good producer using a good coal we are limited by the deposit of tar in the flues and valves. How much of this there is depends not only on the gas temperature at the producer but also on the length of the mains as the tar is deposited as the gas cools. Unless the mains are unusually long a gas temperature of 1100 to 1200 deg. F. is permissable and advisable. With coals which have a tendency to become pasty and gum up or with slack, it will be found necessary to run with temperatures two or three hundred deg. higher. The capacity at which the producer is run has some bearing in the matter as it will be found much harder to keep the temperature down if it is being forced.

With the older types of producers some hand fed and some with automatic feed, the poor coal distribution is the main limiting condition to good practice so far as economy of fuel is concerned. If the coal piles up in certain places on the fire, unless enough hand labor is applied to bar it around and distribute it properly, we get poor gas and coke in the ash. Often times the amount of hand labor necessary to do this is thought prohibitive and as a result the fires are run

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*Iroquois Gas Company, Buffalo, N. Y.

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thin and the gas hot. In this way there are many fires run at from 1800 to 2000 deg. gas temperature simply because it is preferred to spend money for wasted coal rather than for labor. The matter of effecting a balance between the loss of heat and the cost of labor is not a simple one and could be made the subject of considerable study and discussion. However, the writer is of the opinion that in these cases where excessive gas temperatures are carried, more labor could be profitably used. In the average gas house, gas temperatures over 1600 deg. are absolutely unnecessary, even where coal distribution is exceedingly poor and if they are over that, it means that the gas men are not poking their fires but are running them thin deliberately in order to save themselves work.

Hot vs. Cold Gas.

There has been a great deal of discussion and argument on the subject of "Hot vs. Cold Gas." The terms are very loosely used and can mean almost anything. So far as steel plant practice is concerned "cold gas" generally means gas at a temperature of say from 700 to 1200 deg. F. and "hot gas", gas at say 1400 deg. or higher.

There may be isolated cases where it is necessary to furnish so called "hot gas", but they are few and far between. Our problem is in the making of "cold" rich gas and not in the using of it. We know it can be used to advantage.

Action of Gas on Producer Parts.

There are two additional reasons for low gas temperatures, one of which has previously been mentioned. The action of the hot gas on the producer tops, hopper bells, cleaning doors, dampers, valves and linings is very destructive, even when they are water cooled. With the lower gas temperatures their life will be greatly lengthened. Also the formation of excessive amounts of soot is dependent on high temperature. If the gas temperature is kept as near as possible, to the point where tar is deposited very much less soot will be formed.

Instruments.

Most producer manufacturers advise the use of recording steam gauges and pyrometers on their machines. More are being used every day. The pyrometer, by telling the gas man his gas temperature, tells him when to put coal on his fire or when to regulate his feed. The recording steam gauge gives him warning when any extra effort is necessary before his fire gets away from him. It is surprising how quickly a producer may get hot if being forced. It also gives a measure of the capacity at which the machine is being operated. In addition to the value of having permanent records which will be discussed later, recording instruments have the advantage over indicating, because they give the operator a picture of what he is doing. He sees the result of his efforts and those of his "buddy" on the other shift. They tell the story of his day's work and can be made of great value to his superiors in keeping in touch with his work.

Use of Measuring Rod.

The best way of learning the condition of a firebed is by measuring rod. A half inch rod thrust into the fire and left for a moment or so when withdrawn will show the thickness of the different zones. The ash will not effect it, the bottom of the fire will heat it very hot while the upper portions will heat it a cherry red. The coal layer will show on the rod by giving it a tarred appearance. The fire should be measured thus in several places. This is the most reliable method of investigating a fire. Every gas house should be equipped with several of these rods. If their length is equal to the distance between the top of the blower and the producer top, when used they will show at once the condition of the fire and its relative position.

Coke in the Ashes.

The loss of coke in the ash is generally not a large item. There are a few old producers in which the agitators are so constructed that high ash loss, up to 20 per cent of the heat in the coal in some cases, cannot be overcome. They are rapidly being replaced, however, and there are only one or two installations left in use.

Coke in the ash may be caused by too high a proportion of steam in the blast. This is not likely to occur except in cases where a clinkering coal is used and the air is cut down to eliminate trouble. With that kind of coal a small ash loss up to perhaps two per cent is permissable as the small loss is preferable to trouble with clinker.

The quality of the ash is affected very much by the methods of cleaning fires. In the older types of producers there is generally a deeper ash bed carried than in the modern machines. The tendency has been of late years to build the shell shallower and either remove the ashes continuously or else more often than in the deeper old type producers. The common way of cleaning down a fire is to first remove the ash until the bed is arched over and then break it down with bars. This method is most used because it requires the least labor. The result of this method is coke lost in the ash because the section of the fire containing coke and coal is tumbled down into the hole where the ash is removed and is shoveled out.

There is also a tendency on the part of producer operators to clean fires too low because by so doing they do not have to clean them so often and also can more easily clean the clinkers off the side walls when the fire is low and out of the way. This also increases the coke in the ash and in addition is liable to result in burned blower top or base ring casting.

If the fire is poked down at the same time the ashes are being taken out it will gradually settle, there will be little ash loss from this source, the gas making will not be interfered with to such an extent and the producer will recover very quickly. Just enough ash should be taken out to leave at least six inches over the blast hood. When this method of cleaning is used, however, the producer walls will probably have to be cleaned of clinkers whenever it is down as it is hard to get them all off when running higher fires.

While it is important to keep all losses as low as possible, in most cases the carbon in the ash is a small loss. It must be remembered that with ash that is 10 per cent carbon, the per cent heat loss is probably not more than 1 per cent. In average practice, if as much attention were paid to gas quality as to ash loss large savings would be possible.

Waste of Gas.

It is probably true that in all mills more gas is made than is necessary. The heaters are not particularly interested in fuel savings and always want an excess of gas in order to play safe. It is not intended to go into the matter of gas economy at the furnaces as that is another subject entirely and merits attention in itself, but it is tied up with the producer to such an extent that it must be mentioned in connection with the making of excessive amounts of gas in the gas house. On account of this tendency of the heater to waste gas and the gas man run hot, thin fires, in considering a gas house that is not closely supervised we are safe in saying "steam pressures are too high" before we know anything about either the furnaces or the producers. In most mills by economizing in the use of the gas and the making of better gas, steam pressures can be reduced from 10 to 40 per cent. In the laying out of producer plants both the manufacturer and the engineer are likely to put in more than enough capacity in order to protect themselves. This often results in poor practice because on account of the available capacity the crew can get away with anything making up in quantity what is lost in quality. Blowing producers too hard is one of the most common mistakes made in the gas house.

Supervision.

It is to be regretted that too many mill executives do not seem to find time or opportunity to keep in touch with the gas house unless something happens there or there is a shortage of gas. As long as there is plenty of gas no one worries whether there is fuel wasted or not. Probably it is because it is not realized what savings are possible by closer supervision. Why should not a foreman get into his gas house two or three times a day and see that fires are in the proper condition and that steam pressures are down to the lowest possible point consistent with sufficient gas. By keeping closely in touch with the furnaces and producers, wonderful fuel saving can be made. The gas house should be watched as closely as any part of the mill because a big part of the cost of operation goes into the coal which is gasified there.

Records.

The consistent keeping of records of gas house performance is a great help and encouragement because they will show the improvements that are being made. Monthly figures are usually the most convenient to record. The value of records is an additional reason for recording instruments in the gas house. Records that are useful are of steam pressure, gas temperature, gas quality, ash loss, coal consumption and furnace tonnage. A thorough study of these records and their relation to each other gives an idea of what can and should be done at any individual installation that can be arrived at in no other way.

Often it is not possible to get data enough to keep as complete records as this. In this event the ones which are the most important are cool consumption, mill tonnage and gas quality. The first two are generally available but the last means some effort if good records are kept. Gas samples should be taken at regular intervals and analyses run. If apparatus for complete analysis of the gas is not available, determination of carbon dioxide (CO_2) is an excellent measure of the gas quality. If this element is less than five per cent you can be assured that you are making good gas. If complete analysis can be made the heat value can be calculated and records kept of that. In regard to heat values it should be said that lower values should be used. The higher value is arrived at by including the heat of condensation of water which forms when certain constituents of the gas burn. It should not be used because that heat is not available since in all forms of industrial furnaces the waste gases leave the furnace at a temperature higher than the condensation temperature of water under those conditions.

Care and Maintainance.

There is no reason why gas producers should not be given sufficient care as well as any other machine. Due to the fact that many parts of the producer are water cooled, the prevention of leaks is a large part of maintainance. Leaks should be taken care of promptly. They are not only bad on account of their effect on the fire but also because they cause the gas to contain an excessive amount of moisture in the form of superheated steam.

If producers are operated with a reasonably thick fire well up where it belongs it will probably be necessary to clean the side walls of clinkers whenever the producers are down. This should be done whenever possible from the inside with a pick.

It is always advisable to clean out the ashes when a producer is going to be down for any length of time. The lining and lower parts will be kept in better condition than if it is left full of damp ashes.

Ashes are very apt to get densely packed under and about the blast hood seriously interfering with the blast distribution and sometimes even to the extent of cutting down the capacity of the producer to a marked degree. For this reason the ashes about the hood should be cleaned out every few months.

It is very hard to improve practice if the gas producing machinery is not well maintained. The average gas man will not fail to use any excuses for poor gas he may put his hands on, and letting producers get in bad condition gives him an excellent alibi.

Conclusion.

It is often the case that in improving gas house practice considerable opposition is found especially on the part of heaters and gas men. They object to being interfered with. They may have been doing things a certain way for years and it is no small job to bring about a change. Very often the methods are not only not the best but are founded on absolutely wrong ideas. When this is the case the only thing that can be done is to make gas as it should be made and show the man it can be done; then by supervision see that he does it. The average gas man is the product of his environment and very often has had all his years of experience in one house using one kind of coal. Put him on another make of producer or give him a different grade of coal and he may make a mess of it even if he has been making gas all his life.

In improving gas house performance it will be found that all the good that can be accomplished in weeks or months can be lost in a day or two. The gas man will unlearn in an astonishingly short time all he has been taught in a year if he happens to want to. The only way to bring about improvements is to fix cerain conditions and by constant supervision bring the gas house crew to them until they can appreciate for themselves that it can be done and improvements are being made.

Improved gas house practice means not only coal saving but it means also better mill operation and in the long run less trouble for everybody concerned.

Many Changes in Carnegie Organization

Recent Death of William Wigham Causes Several New Appointments

AMBROSE NEVIN DIEHL

Ambrose N. Diehl was born in York County, Pa., on October 20, 1876. His ancestors have resided in Eastern Pennsylvania and Delaware for 225 years. Mr. Diehl entered the public schools and later prepared for college at the York Collegiate Institute, at York, Pa., graduating from there in 1894. He entered the Pennsylvania State College and received a degree of B.S. in 1898. He was elected president of the Athletic Association and received his letters in football and track. He was a member of the Sigma Chi Fraternity and charter member of the Thespians. After graduations, one year was spent in experimental agriculture work in the Pennsylvania experimental station, and in 1899, he took a position in the laboratories of the Carnegie Steel Company, at their Duquesne Works.

Ambrose N. Diehl

After seven months he was transferred to the Blast Furnace Department of the same plant, and six months later was made assistant blast furnace superintendent. In October, 1901, he was given charge of the department and remained in this capacity until 1915 when he served as assistant general superintendent of the Duquesne Steel Works and Blast Furnaces. After being in this position for a year and a half he served as assistant operating vice president in the general offices in Pittsburgh for a similar period when the stress of the war work placed unusual strain on that executive department, and in 1918 he took general charge of the Duquesne Works, as general superintendent.

Mr. Diehl has read a number of technical papers before the American Iron and Steel Institute; the Amercan Institute of Mining and Metallurgical Engineers and the Engineers Society of Western Pennsylvania, serving as a director of both the later organizations. In addition to membership in the above, he is a member of the American Society of Mechanical Engineers; the University Club of New York; the Pittsburgh Athletic Association; Pittsburgh Club; Pittsburgh County Club; Rolling Rock Country Club; Fox Chapel Golf Club; Oakmont County Club; Pross Club; and president of the University Club of Pittsburgh.

I. Lamont Hughes

Mr. Diehl is president of the Duquesne Trust Company; president of the Duquesne Library, and chairman of the Duquesne Branch of the Red Cross. He is a trustee of the Pennsylvania State College, and also chairman of the Athletic Alumni Committee, which controls the athletics and physical education of the institution.

I. LAMONT HUGHES

Mr. Hughes has been with the Carnegie Steel Company or its allied interests for more than a quarter of a century. He was born in Mercer, Mercer County, Pennsylvania, on January 25, 1878. He was educated in the public schools of Mercer and New Castle, Pa., and later, graduated from the high school of North Braddock, Pa. Upon his graduation he took up his

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work in the steel industry, with his first job in the engineering department of the Edgar Thomson Works, of the Carnegie Steel Company, in September, 1897.

He remained here until June, 1901, when he took charge of engineering for the Union Steel Company, at Donora, Pa., and in January, 1905, he went to Youngstown, Ohio, as master mechanic of the bar mills of the Youngstown District of the Carnege Steel Company, the district at the time including mills at Warren and Girard, Ohio, Greenville, Pa., and the Upper and Lower Union Mills of Youngstown.

Mr. Hughes was made assistant general superintendent of the bar mills of the Youngstown District in March, 1906, and five years later, March, 1911, he was made general superintendent of these mills. He continued in this capacity until January 1, 1916, when he was made assistant general superintendent of the entire Youngstown District of the Carnegie Steel Company, whose operations at that time included the construction of the modern steel bar mills and townsite at McDonald, O.

In June, 1916, Mr. Hughes went to Ojibway, Ontario, as general superintendent in charge of the Canadian Steel Company's project at that place. Contemplated operations here were necessarily deferred by the war and Mr. Hughes was transferred in June, 1918, to be general superintendent to the operations being carried on at Neville Island by the United States Steel Corporation for the Government in the construction of projected ordnance plant.

When this project was closed out because of the ending of the war Mr. Hughes was made president of the Lorain Steel Company at Johnstown, Pa., taking up these duties May 1, 1919, and on January 1, 1920, he was made general superintendent of all the operations of the Carnegie Steel Company in the Youngstown District.

The Visual Comparison

By Viggo Sahmel*

The short center belt drive is coming into wider use, due to limitations on space in manufacturing plants. Some years ago a special form of short center drive was introduced which also permits of high pulley ratios, low belt tension, high overloads and minimum belt slip. The arrangement of this short center drive differs in many respects from the ordinary long center drive. The driving and driven pulleys are placed close together. A free pulley is hinged adjacent to the smaller pulley and bears on the slack side of the belt so that it wraps the belt around the smaller pulley. The belt is of such length that the loose side is within a few inches of the tight side and the initial tension in the belt is due solely to the weight of the hinged floating pulley. The most important feature of the drive is the large arc of contact of the belt with both pulleys, resulting in increased grip of the belt on the pulleys for given initial tension and belt size. When the load is applied the belt stretches, but instead of becoming looser, the tension in the slack side is maintained constant by the free pulley and the additional length is automatically wrapped around the small pulley, increasing the arc of contact.

The fundamental formula for belts is $\frac{T_2}{T_1} = e^{fa}$, where T_2 is the tension of the tight side of the belt. T_1 is the tension of the slack side, e the number 2.72, f the coefficient of friction between the belt and the pulley, and a the angle of contact of the belt with the pulley. To increase the capacity of the drive, allowing a given per cent of slip, it is necessary to either increase the width of the belt; increase the initial tension; increase the coefficient of friction f by using sticky belt dressing, wool, canvass or paper pulleys; or increase the arc of contact a. High initial tension is, of course, bad for belt and bearings; sticky belt dressings injure the belt, and the correct crown is eventually worn off wood or paper pulleys. The arc of contact of the belt with the smaller pulley in a certain open drive was 164 deg. On installing the short center drive this was increased to 25 deg. at no load and 251 deg. at full load.

At the Power Show, recently held in New York city, there was exhibited a device which demonstrated visually the relative slip of a short center drive of the type just mentioned and of an open belt drive, which aroused much interest on the part of belt users and engineers generally, not only because of its bearing on belt drives, but also in itself as a method for comparing the speeds of rotating or reciprocating parts.

A motor driven line shaft carries three small pulleys of equal diameter, which are connected respectively by belts to three large pulleys, also of equal diameter. One of the pulleys, which will be called the timing pulley, runs free, while the other two pulleys are fitted with Prony brakes. One of the brake pulleys is belt driven by the short center drive and the other by an ordinary long center drive. The frames carrying the large pulleys are balanced upon pivots and counterweighted, so that equal bearing pressures can be produced on each pulley bearing and approximately equal initial tensions in each belt.

Upon the web of each of the large pulleys is marked a white cross. The three crosses are illuminated by a flicker lamp synchronized with each quarter revolution of the timing pulley. If the two pulleys carrying Prony brakes are running at the same speed as the free pulley, the crosses upon each of them will always be illuminated when in the same position and will appear to be standing still, but if the two brake pulleys are going, say 1 per cent, slower than the timing pulleys, each cross will then be .01 of the circumference of the circle behind the position occupied at the time of the previous illumination, and will appear to the eye to be rotating backward.

The actual slip may be computed by comparing the time of one backward revolution of the observed image of the cross with the speed of the pulley. The slip in per cent is then 100 times the number of revolutions made by the cross in a minute divided by the number of revolutions made by the timing pulley in a minute.

Starting with equal pulley ratios and equal belt thickness, at no load both the short center driven and the long center driven crosses will stand still. On applying a light load, both crosses will start to rotate slowly backward, the cross on the long center drive pulley rotating a little faster than the cross on the short center drive pulley. However, as the load increases, without changing the belt tension, the cross on the long center drive pulley will rotate backward at an increasing rate, while the cross on the short center drive pulley will rotate about as before.

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Chromium—Its Uses and Its Alloys

The effect of chromium in steel is progressive—Nickel chromium steels possess decided advantages for carburizing and case hardening purposes.

By DR. WALTER M. MITCHELL*

PART V.

AN account of a remarkable metal would not be complete without mention of the alloys formed with metals other than iron, some of which are unique in their valuable properties. Chromium will dissolve only slightly in molten zinc, the solidified alloy is hard and brittle. Aluminum and chromium will not mix in all proportions in the liquid state, with low chromium the alloy is very brittle. Chromium is almost insoluble in copper. Chromax bronze, which is more properly classed as a nickel silver contains 3 per cent chromium and 67 per cent copper, with the balance chiefly nickel and zinc. With cobalt and nickel, chromium is soluble in all proportions, both in the molten and solid states, and these alloys are the most important of the series. Chromium silicide and boride have been formed in the electric furnace, and are both very hard, harder even than corundum. The silicide is attacked by aqua regia and hydrofluoric acid, the boride is unattacked by even a mixture of these reagents.

The alloys of nickel or cobalt with chromium, particularly the former on account of their more moderate cost have come into prominence because of remarkable properties, as follows:

(a) Abnormally high resistance to heat and electricity (average 100 microhms per cubic centimeter).

(b) High tensile strength at high temperatures.

(c) Resistance to attack by strong acids and alkalies.

(d) Absence of deformation or deterioration through scaling at high temperatures (up to 2000 deg. F.).

The first notice of these alloys seems to have been in 1896, when Placet patented certain chromium alloys for which he claimed high resistance to heat and anticorrosive properties. It was some 10 years later, however, before the nickel chromium alloys became of consequence when, under patents taken out by Marsh and others, the alloys were made into wires, tape, strips, etc., and used for the manufacture of heating units in the electrical trades. From their use in household appliances such as toasters, irons, hot plates, etc., the field has broadened until we now have car bottom annealing furnaces, hardening furnaces for steel, ovens for core drying in foundries and for baking enamel on automobiles. Later on, under Henderson patents in 1916, the nickel-iron-chromium combination came on the market as a heat resisting alloy for carburizing pots, annealing pans, furnace parts, etc. At present, under various trade names generally ending in "loy" or "ite", there are a dozen or more similar alloys on the market, the general character of all being more or less the same. Some, because of increased nickel and chromium content are more efficient at high temperatures which, naturally, is reflected in their increased cost.

It seems a fairly safe assertion that no really satisfactory heat resisting alloy for high temperatures has yet been developed that does not contain chromium in at least some proportion. The commercially useful nickel-chromium alloys contain from 10 to 35 per cent chromium, the balance nickel or cobalt and iron. For resistance wire, strip, etc., the chromium content is usually low, 10 to 15 per cent, the balance nickel, carbon being low. Nickel formerly used alone for such purposes was not satisfactory as it becomes brittle above 1300 deg. F. This may be avoided by the addition of 10 per cent chromium; and nickel chromium wire or strip, 85 per cent nickel and 15 per cent chromium may be used practically indefinitely up to 1900 deg., even for open type heating units without deterioration.

With increase in chromium content the hardness increases, but when too high the alloy becomes brittle, and hence is of no use where hardness might be a desirable property. Practically all nickel-chromium alloys are capable of being softened and rendered more ductile by heat treatment, and behave as most nonferrous alloys, becoming more ductile when quenched. Originally such alloys were made with metallic chromium and contained no iron, but the cost was almost prohibitive. Now chromium is introduced, as in steel making, through the use of ferrochromium, which necessarily introduces iron, carbon, silicon and other impurities; the cost, however, being considerably reduced. For a given chromium content any increase in iron leads to greater ductility at all temperatures, and this may not always be desirable. All alloys of this class with greater than 10 per cent chromium, together with not more than 25 to 30 per cent iron are probably equally resistant to oxidation at high temperatures. Just how much iron may safely be included depends upon the stress and service they will be required to withstand. Resistance wire for heating purposes may contain up to 27 per cent iron and still give satisfactory service. For castings, such as heat treating equipment, large carburizing pots, annealing pans, etc., the alloy should not have greater than 12 to 15 per cent iron, and not less than 15 to 20 per cent chromium, otherwise distortion is liable to occur. Carbon should be kept low, but need not be less than .30 per cent unless the material is to be drawn into wire or forged. Other elements remaining constant the lower the carbon the more ductile the alloy, as would be expected. With carbon over 1.5 per cent, and chromium over 15 per cent, the proportion of hard carbide increases so that the material becomes unmachinable but the heat resisting qualities are not af-

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*Metal'gist, E. I. du Pont de Nemours & Co., Wilmington, Del.

fected, and because of the higher carbon ferrochromium which may be used, such alloy has the advantage of cheapness.

Nickel chromium alloys of suitable composition will withstand heated gases such as steam, carbon dioxide, carbon monoxide, ammonia, and even pure oxygen up to 2000 deg. F. for indefinite periods without deterioration from scaling. It is true a surface scale does form, but this does not flake off and acts as a protective coating to the metal underneath. The introduction of sulphur compounds, such as hydrogen sulphide or sulphur dioxide is fatal to the highest grade alloy — advertizing literature of the alloy manufacturers notwithstanding to the contrary. There appears to be formed a low melting point compound of nickel and sulphur which is converted into a brittle scale and in a short time causes failure. Consequently it is important that fuels used in carburizing furnaces where nickel-chromium alloy containers are in service should be free as possible from sulphur.

While the nickel-chromium alloys are chiefly known for their oxidation resisting qualities, it is not generally appreciated that they possess unsurpassed corrosion resistance also. Where stainless steels require careful heat treatment and proper machining or grinding of the surface in order to develop maximum stainlessness, the nickel-chromium alloys are corrosion resistant under all conditions and special preparation of the surface is not necessary. They are absolutely immune to atmospheric action in the presence of either fresh or salt water. Compared to stainless steel, these alloys[*] offer greater resistance to those attacking agents, upon which stainless steel has established its reputation, than does this material itself.

The presence of any considerable proportion of impurities in these alloys is objectionable. Aluminum, which itself is used in certain heat resisting alloys is not desirable in the nickel-chromium combination. With 2 parts nickel and 1 part chromium the addition of 7.5 per cent aluminum produces a glass hard alloy which is little affected by heat. During the tungsten shortage at the time of the World War, this peculiar property was made use of by marketing a nickel-chromium-aluminum alloy as a substitute for high speed steel, in which capacity it gave good service. Copper is detrimental as it appears to form low melting point compounds which decrease the efficiency at high temperatures. Silicon up to 2 per cent seems to have no injurious effect; with over 5 per cent the alloys are extremely hard and brittle. Tungsten and molybdenum are sometimes added, as in the alloy known as "Illium", they tend to give a denser alloy and reduce porosity, but appear to add nothing to the heat resisting qualities. Similar to the nickel-chromium alloys an alloy of cobalt, chromium and iron is used for heating elements in electric irons, toasters, stoves, etc. It is said to be superior to the best nickel alloy, but owing to the large proportion of cobalt (60 per cent) it is considerably more expensive.

Mention should be made of Stellite. This is an alloy containing over 50 per cent cobalt with chromium and smaller proportions of tungsten and molybdenum. As originally developed it was a very hard, unforgable alloy, and as its hardness was not affected by heat, it made an admirable material for cutting tools. Because of unforgability it must be cast into approximately the desired form and finished by grinding. Other varieties of Stellite have since been developed which are softer and more malleable, these contain smaller proportions of tungsten and molybdenum. A variety containing cobalt, chromium and iron is known as Festel metal. It is made into knife blades, dental and surgical instruments, etc., for which it has decided advantages as it will take a good cutting edge; and as it is both oxidation and corrosion proof surgical instruments may be sterilized in strong antiseptics or by heating over a flame without injury.

Chromium Surface Coatings.

The valuable properties of chromium from the standpoint of oxidation, corrosion and abrasion resistance have led to experiments on the possibility of forming protective chromium coatings on other metals. Chromium plating by electrolytic processes has been successfully accomplished both in this country and abroad, although the process can as yet hardly be said to have reached the commercial stage. As obtained the coating is bluish-white, hard, polishes well and is untarnishable on exposure to the air, and has withstood successfully uses where nickel and other coatings have failed. It resists[*] the action of ammonia fumes, hydrogen sulphide, nitric acid, and is not attacked by molten tin, zinc, or brass; hydrochloric acid, however, the chief enemy of chromium, attacks it rapidly. From its non-corrodibility in vegetable and fruit acids, and hydrogen sulphide it should make a satisfactory plating for tableware, cutlery, serving dishes, etc., instead of the more tarnishable silver now used. The color also is more attractive, resembling platinum, and is free from the yellowish tinge sometimes present in silver. As it resists oxidation it may be used as a finish for flat irons, hot plates, burners, etc.; and as it has excellent wear resisting qualities and is hard for it could be used in place of the cyanide process for typewriter parts, clock work parts, small gear wheels, etc., where both corrosion resistance and hardness are desirable.

An interesting application of the plating process is the production of chromium wire by plating a copper wire, drawing down and replating, successively, until the original copper core has become negligable in section; the results for all practical purposes being a chromium wire.

Similarly experiments have been conducted with a cementation process of chromium impregnation, analagous to the Calorizing process — chromium being used instead of aluminum. In this process, which has been called "Chromizing", the articles to be treated are packed in a container with a mixture of powdered chromium and aluminum. Oxygen must be excluded, so the container is filled with hydrogen and heated to 2400 deg. to 2500 deg. F. The resulting chromium penetration is somewhat less than a millimeter, the average analysis of the coating layer showing 19 to 15 per cent chromium. The chromized articles showed good resistance to corrosion and oxidation[†], but the product has not yet reached commercial development.

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[*] Trans. Faraday Society, 19, 184.

[*] Trans. Am. Electrochem. Society. 44, 451.

[†] Trans. Am. Electrochem. Society. 43, 351.

The POWER PLANT

Review of Recent Application of Powdered Coal to Steam Boilers*

By HENRY KREISINGER†

THE last three years have shown a marked increase in the application of powdered coal to steam boilers. At present no important power plant decides on the coal-burning equipment without making a thorough investigation of the possibilities of powdered coal. For large stations and for large steam-generating units the indirect system seems to possess an advantage over the direct-firing system and is generally favored for this kind of service. On the other hand, direct firing seems to have some advantages in small industrial plants and small boiler units. This paper deals largely with the indirect system of firing.

This paper gives a brief statement of the trend of the development for the past two years of the application of powdered coal as a fuel for making steam. It includes treatment of developments in furnaces, driers, and mills. Test results are given from boilers and mills in six central stations using pulverized coal as fuel. The author also discusses mill capacities for various grades of coal.

The trend in the development in the various parts of the powdered coal equipment is outlined in the following paragraphs.

Furnace.

Powdered coal gives high efficency because the coal can be burned almost completely with very low excess air. However, low excess air causes high furnace temperature, which in turn causes fusion of ash and erosion of furnace lining. Many of the first attempts to burn powdered coal failed because of the excessive erosion of the furnace lining. Another cause of early failures was the difficulty of removing fused ash from the furnace. A large part of the ash was sprayed in a molten state on the walls and bottom of the furnace. The molten ash sprayed over the walls ran down, washing the brick along with it, and accumulated in a puddle of molten slag at the bottom. This slag could not be removed without cooling the furnace and mining the slag out with picks. In designing a furnace for burning powdered coal there are two problems: (a) The prevention of the erosion of the walls; and (b) easy removal of the ash deposited at the bottom of the furnace.

At present, the trend of the development of the furnace is toward nearly complete water cooling. This apparently is a positive solution for the above two problems. About four years ago a water screen was applied over the bottom of the furnace with the object of preventing fusion of the ash deposited on the bottom, and of making its removal easy. This water screen met with such success that it was soon applied to the back wall of the furnace, where the abrasion was great due to the turning of the flame. Water-cooled side walls are now used in addition to the screens over the bottom and back wall of the furnace. Fig. 1 shows a section through one of the last four furnaces now being installed at the Cahokia Power Station. This furnace has a water screen over the bottom and the rear wall, and fin-tube side walls. All these water-cooled tubes are connected into the circulation of the boiler, so that they really form a part of the boiler. This is a natural development in the design of furnaces. Powdered coal can never be a complete success until the boiler is built around the furnace.

For greatly reducing the abrasion on the furnace walls, the hollow-wall construction has met with considerable success, especially with coal whose ash melts at a comparatively high temperature. In this hollow-wall construction the walls are built with channels between the furnace lining and the outer wall, and through the hollow walls cools the furnace lining and greatly reduces its erosion by the molten ash. Many furnaces of this design are in use and are meeting with considerable success. However, it appears that the water-cooled furnace such as shown in Fig. 1 is to be preferred where high ratings are desired and the coal has very fusible ash. The hollow-wall construction in its various forms is shown in Figs. 2, 3, and 4.

The hollow-wall construction has one commendable feature. No air inlets lead directly from outside into the furnace, through which a flame might puff back into the boiler room and ignite an accidentally caused dust cloud. In the hollow-wall construction the air ports supplying air for combustion open into horizontal air channels. These usually pass half-way around the furnace, so that the flame puffing out of the furnace would have to travel 30 to 40 ft. before reaching the outside of the setting. This feature makes

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†Research Engineer, Combustion Engineering Corporation.

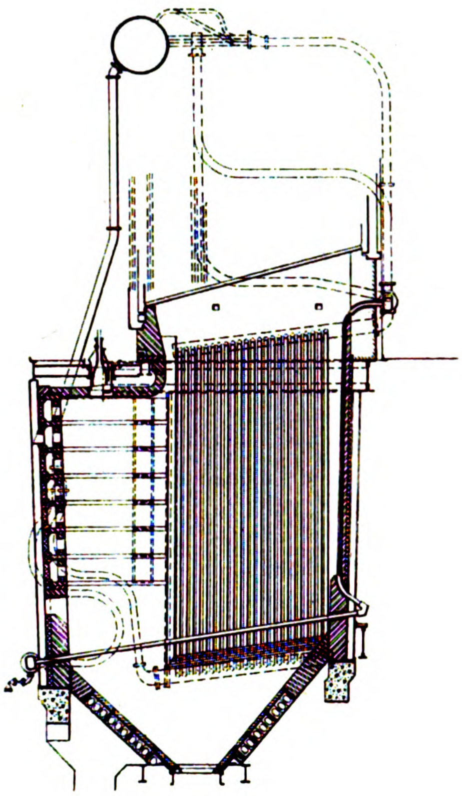


FIG. 1

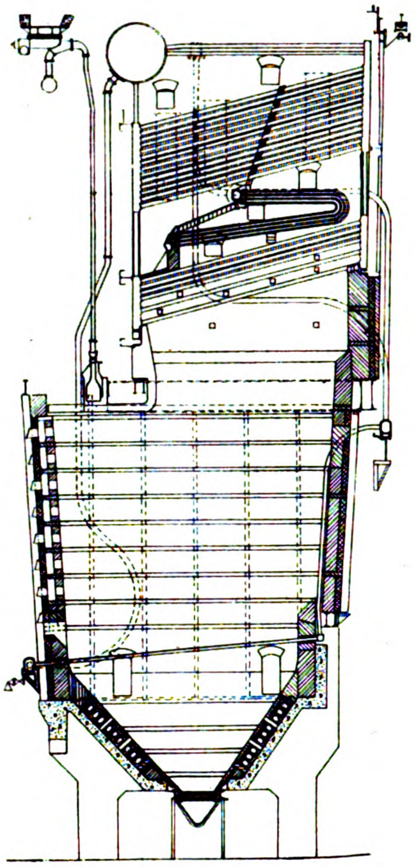


FIG. 2

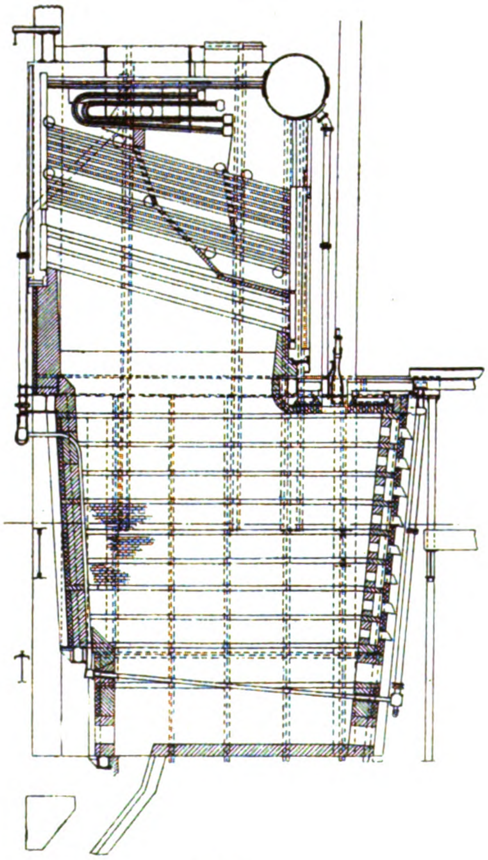


FIG. 3

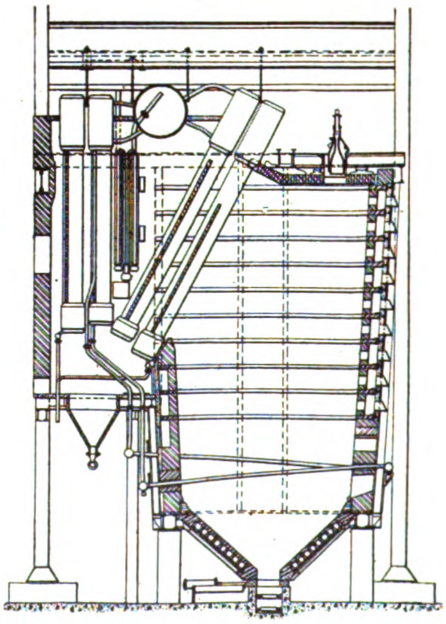


FIG. 4

powdered-coal furnaces safer, and hollow-wall construction also could be applied at least to some extent to water-cooled furnaces in order to make the operation of these furnaces safer.

It is frequently pointed out that pulverized coal requires large furnaces. This is undoubtedly true it the powdered-coal furnace is compared to the old-type stoker installations which usually have a furnace with a very small combustion space. However, when the comparison is made with the modern stoker furnace, the difference in size is not so great. In fact, in the past stoker furnaces were built much too small. In recent stoker installations attention is given to proper design of the furnace and we find stoker installations with 20 to 22 ft. between the stoker and the boiler tubes.

Another reason why the powdered-coal furnace seems large is that most of the powdered-coal furnaces have been installed under very large boilers which are to be operated at high ratings, and consequently the furnaces are made large. These large furnaces are apt to be compared with stoker or hand-fired furnaces of 10 years ago, when a boiler of 5,000 sq. ft. of heating surface was considered large. In present-day power-plant practice steam-generating units of 30,000 sq. ft. of heating surface are quite common. It seems that for these large steam-generating units powdered coal is especially advantageous, because with powdered coal uniformly good combustion can be obtained throughout a large furnace and over a wide range of rating.

TABLE 1.

(Babcock & Wilcox cross-drum boiler, 18,010 sq. ft. of heating surface)

Test No.	2	3	4	5	6	7	8
Duration, hr.	25.35	21.88	25.48	20 20	23.05	21 18	10.80
Coal as fired							
Moisture, per cent	7.08	6.39	7.08	5.89	5.63	6.82	6.77
Ash, per cent	11.47	11.82	11.40	11.04	11.38	11.06	11.38
B.t.u. per lb.	11673	11553	11599	11802	11790	11718	11672
Fired per hour, lb.	8991	13207	8105	16187	11256	13161	17525
Per cu. ft. of combustion space per hr., lb.	0.77	1 13	0.69	1.38	0.96	1.12	1.40
Ash							
Comb. in furnace ash	0.2	..	..	...	...	...	...
Comb. in flue dust	4.8	3.4	4.0	5.1	1.8	2.8	3.0
Water, lb.							
Evaporated per hour	75948	104458	66286	129779	90454	107114	133763
Evaporated per lb. of coal	8.45	7.98	8.18	7.99	8.04	8.18	7.63
B.t u. per lb. of steam	1185.4	1203.8	1187.7	1213.3	1200.3	1210.6	1222.9
Temperatures, deg. fahr.							
Air to furnace	95	91	87	81	84	80	82
Air to feeders							
Gases leaving boiler	483	520	474	564	602	587	589
Feedwater	197	199	194	200	197	198	203
Superheated steam	670	707	668	727	697	718	750
Pressures, lb. per sq. in., abs.							
Superheater	330	332	328	334	330	331	332
Drafts, in. of water							
Furnace	0.13	0.15	0.08	0.34	0.14	0.18	0.22
Uptake	0.37	0.70	0.20	0.47	0.56	0.80	1.00
Pressure feeder air	9.2	12.2	11.3	17.8	13.4	13.5	19.8
Analysis of gases, uptake							
CO_2	14.7	14.7	14.4	14.1	14.5	14.7	14.0
O_2	4.1	3.9	4.4	4.7	4.8	4.3	5.0
CO	0	0	0	0	0	0	0
Heat account in per cent							
Heat absorbed by boiler and superheater	85.9	83.1	83.8	82.1	81.8	84.5	79.9
Loss in dry gases	9.1	10.2	9.2	11.7	10.0	10.5	12.5
Loss in water vapor	5.1	5.4	4.9	5.0	4.8	5.0	5.0
Loss in incomplete combustion	0.6	0.5	0.5	0.6	0.2	0.3	0.4
Radiation Errors and unaccounted for	—0.7	+0.8	+1.6	+0.6	+3.2	—0.3	+2.2
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Powdered-coal furnaces are made large for two reasons: First, to obtain complete combustion; second, to avoid impingement of the flame against the furnace walls, especially with the refractory-lined furnace.

Powdered coal is burned while in suspension in the air. The particles of powdered coal require from one to two seconds to burn almost completely. A large furnace must therefore be provided to permit these particles of coal to stay from one to two seconds in the combustion space. References are sometimes made to locomotive furnaces burning pulverized coal successfully, and to the fact that locomotive furnaces are much smaller than furnaces used in the stationary boilers. However, it must be remembered that in the locomotive, powdered coal usually competes with hand firing, which is comparatively inefficient. In locomotives as much as 20 per cent of the coal fired on the grate may leave the stack in the form of sparks. Powdered coal has therefore a much larger margin in efficiency over the hand-fired locomotive. The locomotive furnace is entirely water cooled and contains little or no refractory to be destroyed by flame impingement. In the central-station practice, powdered coal has a smaller margin in efficiency over the well-operated stoker furnaces and therefore powdered-coal furnaces must be designed to get a better efficiency than the stoker to justify its use.

The second reason for larger furnaces is to reduce the impingement of flame against the refractories. More elbow room must be made for the flame so that it will not gouge into the walls and destroy them in a short time. It is possible that with water-cooled furnaces we may be able to reduce the combustion space to some extent.

Drier.

Some coals require drying in order to make them pulverize easily, to facilitate conveying, and to make feeding of pulverized coal into the furnace more uniform. Other coals may be pulverized and fed to the furnace without drying. In general, coals from the Appalachian and Eastern coal fields may be pulverized and burned without drying. Coals from the Illinois and the Western coal fields must be partly dried before pulverization. The drier is always a nuisance, although sometimes a necessary one. In other cases it is not easy to decide between the difficulties of pulverizing and feeding undried coal, and the expense and trouble of drying it. In some other cases it is comparatively easy to deside to omit driers. There are a number of plants operating with powdered coal which never have had driers installed.

The trend in the development of coal driers is toward a small drier that will dry coal to a sufficient extent as the coal moves toward the mill. Such driers are built in the form of enlarged coal chute, and the coal is dried as it passes through the drier either by waste gases from the boilers, or by exhaust steam. Such driers extract from two to four per cent moisture. Beside abstracting moisture, they preheat the coal, so that when it gets into the mill and is pulverized, it loses moisture readily, and part of the moisture is discharged from the mill system through the mill vent.

The Cahokia station is equipped with driers of this type, using flue gases from the boiler for drying. The gases enter the driers from 300 to 400 deg. F. and leave them at a temperature of 150 to 200 deg. The coal is heated to about 175 deg. F. and passes directly into the pulverizers which are located under the driers. Under these conditions of temperature, the driers may abstract 2 per cent moisture, while the mills abstract 6 per cent moisture from the coal. The coal entering the driers may contain 12 per cent moisture, while the coal leaving the mills may contain only 4 per cent moisture. As far as operating results are concerned, it really makes little difference where the moisture is abstracted, as long as the coal leaves the mills sufficiently dry to be handled by the air transport and fed uniformly by the feeders.

Driers using flue gases from the boilers for drying are adaptable to plants where the coal preparation room is so close to the boiler plant that the gas ducts are not long. The amount of air used in this type of drier is about 3 lb. of gas per pound of coal dried. In other words, about one-quarter of the boiler flue gases is used for drying purposes. These driers are also adaptable only for plants where the flue-gas temperature is not lower than 300 deg. F. With plants having economizers which reduce the temperature of the gases below 300 deg. F., driers of this kind cannot be used.

In installations having the preparation room distant from the boiler plant, and in plants where economizers are used, a steam drier possesses an advantage over the flue-gas drier. This drier is of the same general design as the flue-gas drier, but the coal passages are made of steam-heated grids. As the coal passes through the drier it is heated, and the moisture is partly evaporated. A small amount of air is drawn through the coal, and this air carries the water vapor away. The amount of air used for this purpose is about one pound of air per pound of coal. This quantity of air is small, and only a very small pressure drop through the drier is necessary. The velocities are so low that no noticeable quantity of dust is drawn out with the air. In both types of driers more moisture is driven from the coal if the coal is of a smaller size; that is, coal passing through ¼-in. screen will dry better than coal passing through a 1½-in. and over a ½-in. screen.

Mills.

In the development of mills for large central stations the trend is decidedly toward higher capacity. Most of the mills at present used in central stations have a capacity of from 5 to 9 tons per hour. Some mills are now being installed which have capacity of 15 to 18 tons per hour. The demand seems to be for a mill of about 50 tons capacity. The mills used at present are of the rolling type; that is, the coal is pulverized by rolling a metal roller or ball over the coal and in that way crushing it. A real impact mill is looked up to as having the possibility of being developed into a machine of high capacity, low power consumption, and small wear.

Results of Boiler Tests.

Tables 1 to 5 are taken from a series of steam boiler tests made at six different plants. The plants vary in size from an industrial plant with a unit of about 8,000 sq. ft. of heating surface, to a central station with a unit of 18,000 and 26,000 sq. ft. of heating surface. These tests may therefore be considered as fairly representing the field of powdered-coal application for making steam. The description of the steam-generating units on which the tests were made and the method of making tests are given in Par. 25 et seq. The tests were made by trustworthy engineers and most of the results are accurate with ∓2 per cent, and some of them with ∓1 per cent. The author witnessed practically all of the tests reported in this paper.

The accuracy of the tests is also indicated by the heat accounts, particularly by the last items—radiation, and errors and unaccounted for. In some cases the radiation is computed as a separate item, so that the line headed "errors and unaccounted for" really shows the errors made in collecting the data and the accuracy of the test. This method was applied particularly to the tests made at the West Penn Power Company's plant at Springdale, Pa., because at this plant the coal and water were weighed by Richardson automatic scales. These scales were carefully calibrated, and during the test were closely watched. The last item in the heat account indicates that the automatic scales did very well. The tests are presented in this paper because of the high rating that was obtained with the boiler, particularly on test No. 5. This test was started with a running start; that is, there had been no fire in the furnace for six hours when the test was started, although the boiler was kept on the line during this period. When the test was started the burners were lit, and within less than five minutes the boiler was operating at 300 per cent rating, and soon after that was brought up to above 400 per cent rating. The average for the run, which lasted 24 hours, was 442 per cent.

TABLE 2.

(Ladd boiler, 26,470 sq. ft. of heating surface)

Test No.	1	2	3	4	5
Duration, hours	30.58	31.00	37.07	23.82	24.03
Rating, per cent	150.4	211.3	260.0	285.9	222.9
Coal as fired					
Through 60 mesh, per cent	97.8	96.4	96.4	97.2	98.0
Through 100 mesh, per cent	90.2	88.0	89.6	90.5	91.0
Through 200 mesh, per cent	76.2	72.8	73.3	76.0	77.0
Moisture, per cent	2.0	3.2	3.2	8.4	3.2
Ash, per cent	9.94	7.21	9.30	5.57	6.89
B.t.u. per lb.	13237	13299	13101	13467	13299
Fired per hour, lb.	12912	17723	21750	22900	18270
Per cu. ft. of combustion space per hr., lb.	0.98	1.34	1.65	1.74	1.39
Ash					
Comb. in furnace refuse	0	0	0	0	0
Comb. in flue dust	......	4.0	12.0	34.8	12.0
Water, lb.					
Evaporated per hour	106419	148406	183065	200116	156567
Evaporated per lb. of coal	8.22	8.38	8.42	8.74	8.57
B.t.u. per lb. of steam	1252	1263	1260	1267	1263
Temperatures, deg. fahr.					
Air to furnace	90.3	77.8	77.3	83.8	84.1
Air to feeders	90.3	77.8	77.3	83.8	84.1
Gases leaving boiler	558	611	636	654	615
Feedwater	121.4	116.6	119.6	105.3	111.0
Superheated steam	642	653	654	640	643
Pressures, lb. per sq. in., abs.					
Superheater	242.5	244.2	239.5	237.8	246.4
Drafts, in. of water					
Furnace	0.25	0.18	0.31	0.47	0.35
Uptake	1.28	1.75	1.89	2.15	1.63
Pressure feeder air	4.5	7.5	7.5	7.6	9.0
Analysis of gases, uptake					
CO_2	11.6	12.9	15.3	14.6	13.5
O_2	6.5	5.3	3.1	3.9	5.5
CO	0	0	0	0	0
Heat account in per cent					
Heat absorbed by boiler and sup.	77.8	79.6	80.9	82.2	82.0
Loss in dry gases	13.4	13.6	12.2	12.8	13.1
Loss in water vapor	4.0	4.4	4.3	4.3	4.2
Loss in incomplete combustion	0.5	0.5	0.9	1.6	0.6
Radiation Errors and unaccounted for	+4.3	+1.9	+1.7	−0.9	+0.1
Total	100.0	100.0	100.0	100.0	100.0

In the heat accounts, attention is called to the item "Loss in incomplete combustion." This item includes the combustible in the flue dust, which is by far the largest loss due to incomplete combustion. In many tests with powdered coal this source of incomplete combustion is entirely neglected. With improper furnace design and poor operation the flue dust may be as black as the powdered coal that is fed to the furnace. Usually only the flue gases are analyzed, and a sample of the deposit on the bottom of the furnace may be taken and analyzed. Neither of these two may contain any appreciable amount of combustible, while at the same time a large amount of unburned carbon may be passing out of the boiler with the gases.

We omit the results of tests with Rhode Island graphitic coal, pulverized and burned in a mixture with New River coal. The Rhode Island coal has a very low percentage of volatile matter, and the gases distilled as volatile matter are not combustible. For this reason it is practically impossible to start fires with it alone. However, in a mixture of half and half with New River coal, or even two parts of Rhode Island and one part of New River coal, the mixture ignites readily and is a practical fuel. The economic results obtained with these mixtures compare well with the results obtained when using New River coal.

Results of Mill Tests.

Table 4 gives the results of three series of mill tests made with three different coals at three different plants. The results show that the output of the mill varies to a large extent with the quality of the coal. With Illinois and some of the hard Pennsylvania bituminous coal the capacity of a 6-roll Raymond mill is between 5 and 6 tons. With the coals having granular structure, such as New River and Pocahontas, the capacity is as high as 9 tons per hour. It is higher with dry coal and lower with moist coal.

Cost of Making Steam With Powdered Coal.

Reliable data on the cost of making steam with powdered coal are still meager. It is to be expected that with many powdered-coal plants in operation more data on the cost of making steam soon will become available, so that it will be possible to make a fair comparison with the cost of making steam in stoker plants.

TABLE 3.

Test No.		35	36	38	39	41	40	42
Duration, hr.		14.98	12.47	12.10	15.60	16.35	13.65	11.43
Rating dev. by unit, per cent		157	227	272	192	261	185	220
Coal as fired								
Through 40 mesh, per cent		.....	.....	.....	99.6	.....	99.4	99.9
Through 100 mesh, per cent		.....	.....	.....	85.0	.....	87.6	89.9
Through 200 mesh, per cent		.....	.....	.....	65.4	.....	69.5	70.5
Moisture, per cent		4.7	4.5	5.9	4.4	4.1	4.5	4.6
Ash, per cent		17.4	19.3	18.7	17.8	17.7	21.1	20.7
B.t.u. per lb. of mixture		11543	11308	10997	11577	11424	10788	10806
Fired per hr., lb.	R. I.	3245	4970	5892	4103	6180	5506	6684
	N. R.	3327	4920	5940	4031	5274	2928	3371
Per cu. ft. comb. sp. per hr., lb.	R. I.	0.34	0.46	0.62	0.43	0.65	0.58	0.70
	N. R.	0.35	0.40	0.45	0.42	0.57	0.31	0.35
Water								
Evaporated per hr., lb.		57533	81265	95519	69731	92832	67180	75920
Evap. per lb. of coal, lb		8.75	8.42	8.07	8.57	8.10	7.95	7.91
B.t.u. per lb. of steam		1155	1185	1206	1165	1192	1166	1171
Temperatures, deg. fahr.								
Air to furnace		79	83	78	79	82	83	88
Air to feeders		119	110	106	105	103	106	105
Gases leaving boiler		490	551	578	522	576	535	545
Gases leaving economizer		242	288	304	268	309	270	275
Water to economizer		168	189	188	189	197	194	195
Water to boiler		262	284	293	278	305	291	287
Superheated steam		583	639	690	610	669	615	626
Pressures, lb. per sq. in. abs.								
Boiler		234	235	239	237	239	233	237
Superheater		221	224	227	230	229	227	227
Drafts, in. of water								
Furnace		0.15	0.17	0.17	0.09	0.23	0.08	0.16
Gases leaving boiler		0.30	0.58	0.71	0.39	0.82	0.41	0.54
Gases leaving economizer		0.69	1.44	1.87	0.90	2.09	1.00	1.85
Press. feeder air		14.1	14.4	14.6	14.4	15.2	14.1	14.3
Analysis of gas								
CO_2 leaving boiler		14.0	13.9	13.8	14.1	13.8	13.9	14.6
CO_2 leaving econ.		13.9	13.7	14.0	14.3	13.8	13.8	14.7
Heat account								
Heat absorbed by boiler and superheater		82.0	81.2	80.8	79.8	76.3	78.7	78.9
Heat absorbed by boiler, superheater and economizer		88.3	88.3	88.4	86.2	84.4	85.0	84.8
Loss in dry gases		3.9	4.8	5.4	4.3	5.4	4.1	3.8
Loss in water vapor		2.9	3.0	3.2	2.9	3.1	3.3	3.3
Loss in incom. comb. Radiation Errors and unaccounted for		4.9	4.9	4.0	6.6	7.1	8.6	8.1

In the past, unfair deductions for powdered coal were often made by estimating the cost of preparing pulverized coal and then comparing it with the value of the coal saved by the higher thermal efficiency of powdered coal over the stoker. All comparisons should be made on the basis of total cost of preparing and burning pulverized coal, and the total cost of burning with stokers. However, such cost can be compiled best by the operating engineers. It is hoped that some such data will be presented in the discussion of this paper. The following method of presenting cost data is suggested:

COST OF BURNING ONE TON OF COAL

	Powdered-coal plant	Stoker plant
A. Operating labor	$...........	$..........
B. Power	....	....
C. Maintenance	....	....
D. Fixer charges	....	....

Description of Boilers and Furnaces and Method of Making Tests.

The furnaces on which the tests were made were fired vertically downward, the flame turning up near the bottom, making a U-shaped path through the furnace. About 15 to 20 per cent of the air needed for combustion was supplied with the coal, another 10 to 15 per cent of the air was supplied through the burners around the nozzles, and 60 to 70 per cent through the hollow walls.

Test at Cahokia Power Plant of the Union Electric Light & Power Co., St. Louis, Mo.

The boiler shown in Fig. 2, was a Babcock & Wilcox crossdrum, 20 tubes high and 38 tubes wide, with 18,010 sq. ft. of heating surface. It was equipped with a Babcock & Wilcox super-heater of 4070 sq. ft. of heating surface placed in an interdeck chamber above the sixth row of boiler tubes.

The furnace was of the hollow-wall construction with a steel casing. It was equipped with 10 Lopulco fantail burners and a water screen over the bottom and rear wall of the furnace, with 587 sq. ft. of heating surface exposed to fire. The water screen consisted of 4-in. tubes spaced 10.85 in. between centers. It was connected to the boiler drum by two 6-in. downcomers and two 8-in. risers. The combustion space above the water screen was 11,750 cu. ft. The average distance between arch and water screen was 22 ft.

The tests were made by the engineers of McClellan & Junkersfeld, Inc., and of the Union Electric Light & Power Co. Water was weighed in two special test tanks placed on a standard platform scale. Coal was weighed in the weighing tanks of the Quigley air transport as it was delivered to the bin of the test boiler. The results of the tests are given in Table 1.

The coal used was Illinois coal of the following typical composition:

	Per Cent
Moisture	12.91
Ash	11.64
Carbon	60.74
Hydrogen	4.00
Nitrogen	1.15
Sulphur	1.32
Oxygen	8.24
Volatile	31.9
Fixed carbon	43.55

Tests at River Rogue Plant of the Ford Motor Company.

The results of the tests are given in Table 2. The boiler was a Ladd water-tube boiler with 26,470 sq. ft. of heating surface. It was equipped with a locomotive superheater made by the Superheater Company and placed between the boiler tubes in the first pass of the boiler. The heating surface of the superheater was 3,140 sq. ft.

The furnace was of solid-wall construction equipped with 12 Lopulco burners, six burners on each side of the boiler. There was no water screen in the furnace. The total combustion space was 13,200 cu. ft. Coal was fired vertically downward. The distance between burner arches and the bottom of the furnace was 20 ft.

The tests were made by the engineers of the River Rouge Plant in co-operation with the test engineers of Combustion Engineering Corporation. Water was weighed in three special tanks placed on standard platform scale and fed to the boiler through a separate test line. Powdered coal was weighed as it was delivered to the boiler bins, in special weighing tanks suspended from standard scales.

The coal used on the tests was a mixture of two Kentucky coals from Banner Fork and Pond Creek mines, and had the following typical composition:

	Per Cent
Moisture	2.0
Ash	9.94
Carbon	73.69
Hygdrogen	4.50
Sulphur	0.53
Nitrogen	1.20
Oxygen	8.14
Volatile matter	33.4
Fixed carbon	54.5

Tests at No. 3 Plant of Rochester Gas and Electric Company.

The boiler, Fig. 4, was of the Bigelow-Hornsby type, having 8,750 sq. ft. of heating surface. It was equipped with a Foster superheater of 1,055 sq. ft. of heating surface, and a Sturtevant cast-iron-tube economizer with 2,390 sq. ft. of heating surface.

The furnace was of hollow-wall construction with a steel casing. It was equipped with four fantail Lopulco burners and a water screen over the bottom of the furnace having 157 sq. ft. of heating surface. The combustion space of the furnace was 4,200 cu. ft. above the water screen and 655 cu. ft. below the screen. The distance between the burner arch and the water screen was 26 ft.

The tests were made by the plant test engineers in co-operation with the test engineers of the Combustion Engineering Corporation. Coal and water were weighed with standard scales. The results are given in Table 3.

The coal burned was Pennsylvania Lucerne Mine coal. The following is a typical composition:

	Per Cent
Moisture	3.0
Ash	11.4
Carbon	71.75
Hydrogen	4.74
Nitrogen	1.27
Sulphur	2.15
Oxygen	5.73
Volatile matter	28.0
Fixed carbon	57.6

Test at Springdale, Pa., Plant of the West Penn Power Company.

The boiler was a Babcock & Wilcox cross-drum, 15 tubes high and 42 tubes wide, the tubes being 20 ft. long. The heating surface was 15,326 sq. ft. The boiler was equipped with a Babcock & Wilcox superheater located above the first pass, and having 3,860 sq. ft. of heating surface.

The furnace was of hollow-wall construction with a steel casing. It was equipped with eight Lopulco burners and a water screen over the bottom and rear wall of the furnace, and having 480 sq. ft. of heating surface. The water screen consisted of 4-in. tubes spaced 14 in. between centers and connected to the boiler drum with two 6-in. downcomers and two 6-in. risers. The distance between the burner arch and the water screen was 23 ft.

The tests were made by the test engineers of the West Penn Power Company. Water and coal were weighed with Richardson automatic scales. The coal used was Pittsburgh coal. A representative analysis of the coal is as follows:

	Per Cent
Moisture	1.51
Carbon	73.44
Hydrogen	4.76
Oxygen	6.28
Nitrogen	1.45
Sulphur	0.71
Ash	11.85
Volatile matter	35.0
Fixed carbon	51.6

Tests at the Plant of Penn Salt Company, Wyandote, Mich.

The boiler was a Babcock & Wilcox cross-drum boiler, 14 tubes high and 27 tubes wide, having 8,220 sq. ft. of heating surface. The boiler was equipped with Babcock & Wilcox superheater.

The furnace was of hollow-wall brick construction, equipped with four Lopulco fantail burners and a water screen over the bottom of the furnace. The screen consisted of 4-in. tubes spaced 14½ in. centers, connected to boiler drum with two 6-in. downcomers and two 6-in. risers, and having 236 sq. ft. of heating surface. The combustion space was 3,360 cu. ft. The distance between burner arch and the water screen was 14 ft.

TABLE 4.

ILLINOIS COAL [1]

Test No.	1	2	3	4	5	6	7	8
Total mill hours	16.33	13.99	27.72	17.05	58.86	35.23	30.15	48.78
Coal per hour, tons	5.97	5.24	5.27	6.00	6.68	5.70	4.31	4.06
Moisture in coal, per cent	4.6	6.0	5.2	4.1	5.6	3.7	6.1	6.2
Kw. per hour	77.5	78.0	77.9	78.3	79.3	78.7	77.2	77.4
Power per ton of coal, kw-hr.	13.0	14.9	14.7	13.4	14.3	14.1	18.4	19.6

Average fineness of coal: Through 100 mesh 96 per cent, through 200 mesh 76 per cent.

Tests 1 to 6, dried coal; tests 7 and 8, undried coal.

PENNSYLVANIA COAL, NATRONA MINE, UNDRIED [2]

Test No.	1	2	3	4	5	6	7	8	9	10	11
Total mill hours	10.92	11.17	6.93	6.35	9.90	10.65	14.26	14.10	13.08	13.48	9.92
Coal per hour, tons	5.04	5.04	5.40	5.35	4.95	4.86	4.56	4.61	4.86	4.98	4.97
Moisture in coal, per cent	2.4	2.1	1.8	2.1	1.9	2.4	2.1	1.8	2.0	1.9	1.6
Kw. per hour	63.7	67.6	69.3	68.0	63.9	66.1	61.6	59.1	69.0	67.0	65.0
Power per ton of coal, kw-hr.	12.45	13.41	13.14	12.75	12.96	13.56	13.50	12.81	14.25	13.38	13.38

Average fineness of coal: Through 100 mesh 95 per cent, through 200 mesh 76 per cent.

NEW RIVER COAL, UNDRIED [3]

Test No.	1	2	3	4	6	7	9
Total mill hours	8.6	6.8	5.1	5.8	5.8	4.6	5.6
Coal per hour, tons	9.9	8.85	8.8	8.1	8.7	8.3	7.1
Moisture in coal, per cent	2.5	2.9	2.6	2.7	2.6	3.1	2.0
Kw. per hour	112	106	104	99	105	105	87
Power per ton of coal, kw-hr.	11.4	12.0	11.8	12.2	12.1	12.7	12.3

Average fineness of coal: Through 100 mesh 98.5 per cent, through 200 mesh 81.5 per cent.

Tests were made by the engineers of the Penn Salt Company in co-operation with the test engineers of the Combustion Engineering Corporation. The coal was weighed on standard scales in lots of 1,000 lb. as it was delivered to the pulverizing mill. The water was weighed in two special test tanks placed on standard platform scales. The coal used on these tests was Pennsylvania coal from the Natrona mine.

Test at the Plant of the United Railways of Providence, Providence, R. I.

The boiler tested, of the Bigelow-Hornsby type, had 12,660 sq. ft. of heating surface. It was equipped with Foster superheater of 6,060 sq. ft. of heating surface, and a Foster economizer of 7,488 sq. ft. of heating surface.

The furnace was of hollow-wall construction with a steel casing. It was equipped with eight fantail Lopulco burners and a water screen over the bottom of the furnace having 320 sq. ft. of heating surface. The combustion space of the furnace was 9500 cu. ft.

(Concluded on page 103)

TRADE PUBLICATIONS AND NOTES

Edward T. Moore, formerly electrical engineer of the Holcomb Steel Company, announces the opening of his office at 500 Cahill Building, Syracuse, N. Y., for the general practice of consulting engineering and the manufacture of the Moore electric power regulator. Mr. Moore will specialize in industrial plant problems and electric furnace installations with which the Moore electric power regulator is closely allied. Mr. Moore has been a frequent contributor to The Blast Furnace and Steel Plant, his researches into power factors being always of timely value to the steel industry.

Combustion Engineering Corporation announces that Mr. James Cleary, formerly manager of their Philadelphia office, will assume management of the Detroit and Cleveland territories with headquarters in Detroit. Mr. Frank Henderson will continue in charge of the Cleveland office. Mr. Joseph Lapp, formerly in charge of the Detroit office, has been assigned to New York for special work. The Detroit office has been removed from the Penobscot Building to the Book Building.

The Pressed Steel Car Company, of McKees Rocks, Pa., has just completed an arrangement with the Metropolitan Life Insurance Company for the establishment of a group insurance program for the benefit of its employes and those of five subsidiary concerns, all located in McKees Rocks or Allegheny. Including the life insurance coverage on workers at the company's properties in Koppel, Pa., also protected several months ago by a Metropolitan group policy, the total now amounts to about $3,600,000 on more than 3,600 employes.

Glenn G. Howe Dies at Muskegon, Mich.

On Christmas day, 1924, Mr. Glenn Grenville Howe, for many years Senior Vice President of the Link-Belt Company, passed away at his home in Muskegon, Mich., after a long illness.

His first connection with the Link-Belt organization was as a 16-year-old office boy in 1877. Following his mechanical bent, he drifted into the manufacturing department, and later became the superintendent of the Ewart Manufacturing Company. He knew the chain business thoroughly in practice and theory, and his connection with it was marked by several important improvements.

When the three related interests, the Ewart Manufacturing Company, the Link-Belt Machinery Company and the Link-Belt Manufacturing Company, were merged into one, as the Link-Belt Company, in 1906, Mr. Howe became vice president, in charge of the company's Indianapolis operations. It was under his directions that the Belmont Malleable Iron Foundry and Ewart assembly plant were built, in 1913; and he continued as senior vice president until failing health led to his retirement from active business. Later, with returning health, he organized the Howe Chain Company, at Muskegon, Mich., serving as president of an organization which became a decided factor in chain making, through its thorough knowledge of the art.

Review of Applications of Powdered Coal

(Continued from page 102)

above the water screen. The distance between burner arch and the water screen was 26 ft.

The results of the tests are not here included. They were made by the test engineers of the United Railways of Providence in co-operation with those of Combustion Engineering Corporation. Coal was weighed in lots of 2,000 lb. in a special hopper placed on standard platform scales. Water was measured in two special test tanks with conical bottom and top.

TABLE 5.

(Babcock & Wilcox cross-drum boiler, 15,326 sq. ft. of heating surface)

Test No.	2	3	4	5	6	7
Duration, hours	24	24.07	23.37	22.58	45.92	23.06
Rating, per cent	213.8	218.4	309.1	383.0	125.2	441.8
Coal as fired						
Through 60 mesh, per cent						
Through 100 mesh, per cent	82.93	92.74		86.72	85.16	87.67
Through 200 mesh, per cent	62.98	77.95		66.58	63.72	64.68
Moisture, per cent	1.37	1.12	1.47	1.84	1.61	1.61
Ash; per cent	11.26	12.23	11.51	11.35	11.85	9.46
B.t.u. per lb.	13246	13114	13356	13260	13244	13469
Fired per hour, lb.	10188	10448	15076	18890	5865	22318
Per cu. ft of combustion space per hr., lb.	0.82	0.84	1.216	1.52	0.47	1.80
Water, lb.						
Evaporated per hour	89158	91516	127171	155314	53390	177383
Evaporated per lb. of coal	8.75	8.76	8.44	8.22	9.10	7.96
B.t.u. per lb. of steam	1232.3	1227.2	1248.5	1267.4	1206.5	1280.3
Temperatures, deg. fahr.						
Air to furnace	59	56	61	52	68	48
Air to feeders	141	141	133	127	136	104
Gases leaving boiler	555	556	608	665	494	691
Feedwater	94.	98.	95.	98.	94.	88.
Superheated steam	571	570	602	633	527	647
Pressures, lb. per sq. in. abs						
Boiler	321	323	327	336	320	344
Superheater	318	320	322	331	319	337
Drafts, in. of water						
Furnace	.05	.05	.15	.24	.04	.30
Uptake	.42	.88	.94	1.62	.10	2.22
Pressure feeder air	10.2	8.9	15.0	17.1	8.5	19.2
Analysis of gases, uptake						
CO_2	12.9	13.6	13.5	13.2	12.5	13.1
O_2	6.1	5.6	5.5	5.7	6.7	5.5
CO	.06	.05	.08	.08	.01	.16
Heat account in per cent						
Heat absorbed by boiler and superheater	81.4	81.9	78.9	78.5	82.8	75.5
Loss in dry gases	12.9	12.4	13.5	15.5	11.6	16.6
Loss in water vapor	4.4	4.4	4.5	4.7	4.3	4.7
Loss in incomplete combustion	1.0	1.0	1.5	2.0	1.0	2.5
Radiation	0.7	0.7	0.5	0.4	1.4	0.3
Errors and unaccounted for	−0.4	−0.4	+1.1	−1.1	−1.1	+0.4
Total	100.0	100.0	100.0	100.0	100.0	100.0

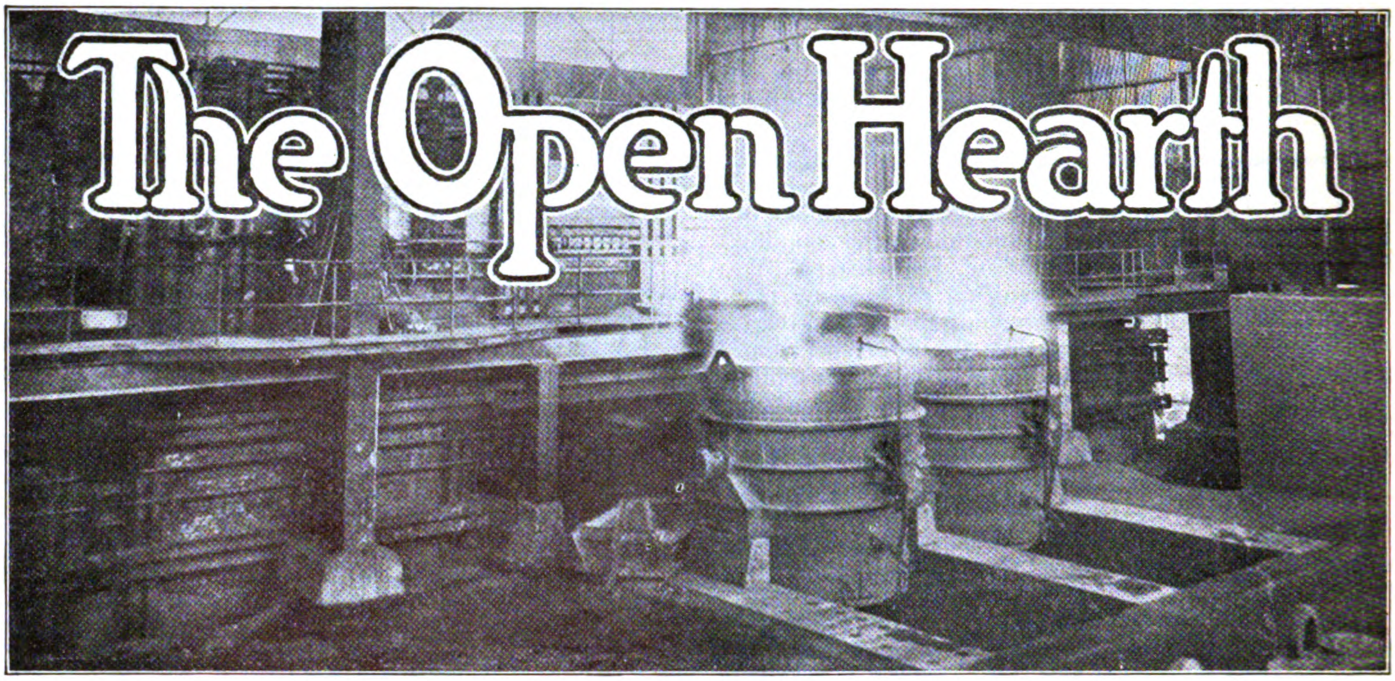
The coal used was New River coal and Rhode Island coal. The following are typical analyses of the coals:

NEW RIVER

	Per Cent
Moisture	2.52
Ash	8.0
Carbon	78.71
Hydrogen	4.46
Nitrogen	1.31
Sulphur	6.8
Oxygen	4.32
Volatile matter	21.28
Fixed carbon	68.2

RHODE ISLAND (CRANSTON MINE)

	Per Cent
Moisture	9.71
Ash	25.71
Carbon	62.60
Hydrogen	0.29
Sulphur	0.68
Nitrogen	0.08
Oxygen	0.93
Volatile matter	2.60
Fixed carbon	61.98
Btu. as received	9,770 per lb.



Open Hearth Record Broken by Edgar Thomson Furnaces

The Edgar Thomson open hearth plant of the Carnegie Steel Company last week established a world record for production from open-hearth furnaces of the stationary type in a 24-hour run. The plan has been running at capacity production.

The world record established by the plant surpassed the best previous daily tonnage mark by the wide margin of 694 tons. This feat, according to O. H. Hartsuff, general superintendent, was made possible only through the whole-hearted co-operation given John W. Kagarise, open-hearth superintendent and and his assistant, John R. Evans, by the men under them.

The world's record was achieved without accident or injury to any man and in addition to this another feature of the accomplishment was the high quality of material produced, plant officials pointed out.

Mingo Junction to Build Open-Hearths

The Carnegie Steel Company, Pittsburgh, Pa., has approved plans for the construction of seven new open hearth furnaces at its plant at Mingo Junction, near Steubenville, Ohio, and purposes to proceed with the project in March. The new structures will adjoin present buildings at the works, and with auxiliary buildings and machinery, are estimated to cost approximately $5,000,000. The company has work in progress on a new coke unloading dock at this plant, and will push the structure to early completion, including the installation of a power plant. Considerable other work and improvements are being carried out at other important mills of the company, including a new boiler house, additional metal mixer and other miscellaneous work at the Edgar Thomson Works; rebuilding and modernizing of different mills at the Homestead Works, including, as well, additional equipment at this latter plant; reconstruction of blast furnace No. 1, at the Ohio Works; and reconstruction of blast furnace No. 2, at the Duquesne Works, with the installation of a new electric substation for power service at this plant.

The Ohio Seamless Tube Company, Shelby, Ohio, has placed a contract with the Standard Engineering Company, Ellwood City, Pa., for additional equipment for the manufacture of their line of cold drawn seamless alloy tubes. With this equipment in place the Ohio Seamless Tube Company will have considerably increased their capacity of Seamless Cold Drawn Tubes. These alterations and additions to their present equipment will result in the Ohio Seamless Tube Company's present plant being the most modern for the manufacture of alloy steel tubes.

Mr. S. G. Worton has been appointed General Superintendent of Duquesne Steel Works and Furnaces at Duquesne, Pa., vice Mr. A. N. Diehl elected Vice President.

The Okonite-Callender Cable Company, Inc., has purchased a plant in Paterson, N. J., where it will manufacture lead-covered paper insulated cables.

The Weirton Steel Company, Steubenville, Ohio, is planning for a number of improvements at its local plant, and purposes to develop the works to the same degree of efficiency for heavy commercial production as the plants at Weirton and Clarksburg, W. Va. The project will consist of the installation of additional equipment in several departments, as well as electrification of different portions of the works, replacing present steam-driven apparatus. The plant recently was placed in service, following a shut-down, and will be maintained on the active list for an indefinite period.

Mr. William Findlayson, formerly Assistant to the Master Mechanic, has been named Superintendent of the Mechanical Department of the Homestead Steel Works, Carnegie Steel Company, succeeding Richard Moon whose sudden death is recorded in this issue.

Mr. Horace E. Smythe, President of the S. R. Smythe Company, Pittsburgh Engineers, died January 9, 1925.

Some Pointers on By-Product Coke Oven Operations

Gas Companies Do Record-Breaking Business

The gas utilities of the United States sold 405 billion cubic feet of manufactured gas in 1924, according to figures made public by the American Gas Association. This is an increase of 20 billion cubic feet over 1923, and a six-year increase of 100 billion cubic feet.

Steady expansion of plant and distribution facilities during 1924 enabled the companies to connect 440,000 new customers to their lines, making a total of 10,240,000 customers as of December 31, 1924, the association states. Total population served by gas is in the neighborhood of 52,000,000.

Unprecedented use of gas in industrial heating processes is chiefly responsible for the large increase in sales in recent years. During the last 10 years the industrial use of gas jumped 1,000 per cent, and indications are that 1925 will establish a new high record in consumption. In the meantime, household use of gas has been making steady increase. Sales of merchandise last year by gas companies alone was about $50,000,000. More than 800,000 ranges, 450,000 water heaters and 500,000 space heaters were connected to lines.

O. L. Chapman has joined the Sales Organization of the Scott Valve Manufacturing Company of Detroit. Mr. Chapman is widely known in the Industrial Field throughout the United States, and will devote his time to the application of Valves to Manufacturing Plants and similar lines of Industry.

We note with interest the unique announcement made by S. F. Bowser & Company entitled "When Emergencies Arise." As an example of what an old reliable concern is able to say on the important subject of adequate service rendered to its host of customers, this bulletin is worth sending for and worth reading.

Oil and Gas Power Week April 20-25

At a recent conference of co-operating organizations in the rooms of the American Society of Mechanical Engineers, the date for the first Oil and Gas Power Week was set for April 20-25, 1925. The week will be celebrated by techical meetings to be held in selected cities throughout the country—at least 25 in number. Industrial plants in the selected communities will be asked to co-operate. Topics to be studied during the week will be the use of the Diesel engines in central stations, industrial plants and on shipboard, methods of testing oil and gas negines, and problems in design, weight reduction, operating costs, etc.

Co-operating with the American Society of Mechanical Engineers in plans for the week are the following organizations: National Association of Stationary Engineers, American Society of Marine Engineers, American Chemical Society, American Society of Naval Engineers, National Safety Council, American Society of Agricultural Engineers, U. S. Chamber of Commerce, Society of Naval Architects and Marine Engineers, U. S. Bureau of Mines, and the U. S. Department of Commerce.

Compressed and Liquefied Gases

The Department of Commerce announces that, according to the data collected at the biennial census of manufactures, 1923, compressed and liquefied gases to the value of $34,188,407 were manufactured during the year, an increase of 35.7 per cent as compared with $39,930,984 in 1921, and of 25.7 per cent as compared with $43,113,322 in 1919.

The production of the principal gases included in this group was as follows: Oxygen, 2,019,589,000 cu. ft., valued at $22,925,934, an increase in value of 64.2 per cent as compared with $13,964,952 in 1921; acetylene (not including acetylene distributed through mains), 522,349,000 cu. ft., valued at $13,080,232, an increase in value of 74.3 per cent as compared with $7,504,325 in 1921; anhydrous ammonia (not including production by gas companies), 11,765 short tons, valued at $6,414,667, an increase in value of 12.4 per cent as compared with $5,708,820 in 1921.

The statistics for 1923 and 1921 are summarized in the statement below. The figures for 1923 are preliminary and subject to such correction as may be found necessary upon further examination of the returns.

	1923	1921
Total value	$54,188,407	*$39,930,984
Acetylene†		
Number of establishments	58	49
M cu. ft.	522 349	290,854
Value	$13,080,232	$7,504,325
Hydrogen		
Number of establishments	51	46
M cu. ft.	141,754	99,104
Value	$1,151,778	$639,553
Oxygen		
Number of establishments	‡121	94
M cu. ft.	2,019,589	1,059,825
Value	$22,925,934	$13,964,952
Anhydrous ammonia§		
Number of establishments	12	*12
Tons (2,000 pounds)	11,765	*10,566
Value	$6,414,667	*$5,708,820
Carbon dioxide (carbonic acid)		
Number of establishments	45	43
Tons	25,548	27,308
Value	$4,992,363	$6,374,619
Chlorine		
Number of establishments	12	13
Tons	36,868	28,611
Value	$2,751,172	$3,188,750
Nitrous oxide (laughing gas)		
Number of establishments	12	8
M gallons	45,267	42,016
Value	$730,644	$747,979
Other gases¶		
Value	$2,141,617	$1,801,986

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*The total value of products and the figures for anhydrous ammonia as here shown for 1921 differ from those heretofore published because of the inclusions in the previous reports and the noninclusion in this table of data showing the production, by 19 gas companies, of 3,253 tons of anhydrous ammonia valued at $489,851.

†Not including acetylene distributed through mains.

‡Establishments using electrolytic method alone, 59; those using compression method alone, 57; those using both methods, 5.

§Not including production by gas companies.

¶Sulphur trioxide, sulphur dioxide, carbohydrogen, argon, blau gas, nitrogen, etc.

NEWS OF THE PLANTS

The Dunbar Corporation, Dunbar, Pa., recently organized to take over the local property of the American Manganese Company, has plans under consideration for extensions and improvements in the plant, which now consists of two 250-ton blast furnaces and auxiliary buildings, by-product coke ovens, etc., as well as sand rock quarries, coal lands, etc. The furnaces will be improved to develop maximum output under greatest efficiency, while equipment is contemplated in other divisions of the plant for complete modernization. The rock quarries will be provided with modern apparatus, and are expected to be worked to full capacity at an early date. The new corporation is headed by William P. Gest, Philadelphia, Pa., as president; R. M. Marshall, Dunbar, Pa., vice president and general manager, and Edward S. Dunn, Philadelphia, treasurer.

The Kansas City Steel & Wire Company, Kansas City, Kan., Harry J. Kaelin, City Hall, treasurer, plans for the construction of two open hearth furnaces, each with capacity of about 50 tons, at its proposed plant on site selected on Twelfth Street, fronting on the line of the Terminal Railway. Work on the different steel mill structures, consisting of two main buildings, 100x150 feet, and 80x250 feet, will begin at an early date, and list of equipment arranged for installation. The entire project will cost approximately $500,000.

The Youngstown Sheet & Tube Company, Youngstown, Ohio, has plans under way for the construction of a new skelp and sheet bar mill at its East Youngstown plant. The proposed plant will replace an existing unit, and will be equipped to provide close to 50 per cent increase in output. It will be one-story, and is expected to cost in excess of $400,000, including equipment. Machinery contracts will be arranged at an early date.

The Colorado Fuel & Iron Company, Pueblo, Colo., will carry out an expansion and improvement program at its local steel works, estimated to cost close to $3,000,000, including equipment. An important feature of the project will be the complete electrification of all departments of the works, and considerable additional equipment will be installed for this purpose, replacing machinery heretofore steam-operated.

The Hudson Valley Coke & Products Corporation, Troy, N. Y., is arranging plans to expand the capacity of its blast furnace from 350 to 450 tons per day, and will proceed with the work at an early date. At the same time, it is expected to increase the battery of coke ovens from 44 to 55, and foundations are now in progress. The company was organized recently to take over and expand the local steel properties, and will expend close to $6,000,000 in this work instead of $5,000,000, as originally anticipated. It is purposed to have the blast furnaces ready to blow in during the coming summer.

The Champion Spark Plug Company, Toledo, Ohio, has begun the construction of a new addition to its plant, to be equipped and used exclusively as a mill for cold drawn steel service. It will be one-story, located on site adjoining the present works. The initial machinery installation is expected to develop an output of about 60 tons of steel daily. The works will cost in excess of $150,000, it is stated, including equipment.

The Seneca Iron & Steel Company, Erie County Bank Building, Buffalo, N. Y., has preliminary plans under consideration for the erection of a number of additions to its plant at Blaisdell, N. Y., comprising one-story units, estimated to cost close to $550,000, including equipment. It is expected to arrange a list of equipment to be installed at an early date.

The Republic Iron & Steel Company, Youngstown, Ohio, will soon begin work on a new by-products coke plant at Birmingham, Ala., for which a contract recently was awarded to the Koppers Company, Pittsburgh, Pa. The plant comprises a battery of 57 ovens, with a coal carbonizing capacity of about 50,000 tons per month, designed to produce close to 37,500 tons of coke in this period. The units will be of the Koppers-Becker type, and will be used in connection with the three blast furnaces of the company in this district. The new coke works are scheduled to be completed and ready for service before the close of the present year. The company has work in progress on a new butt weld mill at its tube works, and purposes to have the structure ready for service at an early date.

The Union Drawn Steel Company, Beaver Falls, Pa., is planning for extensions at the plant of the Frasse Steel Works, Inc., Hartford, Conn., recently acquired, and purposes to develop this property for its entire New England and eastern trade. The present works have a capacity of about 30,000 tons of cold drawn steel per year, and additional modern equipment will be installed to increase this rating considerably. The work will be placed in progress, it is stated, in the near future. The company is now operating five plants, including the new Hartford acquisition, the others consisting of two main mills at Beaver Falls, and plants at Gary, Ind., and Hamilton, Ont., respectively.

The Minnesota Steel Company, Duluth, Minn., a subsidiary of the United States Steel Corporation, has work under way on the remodeling of its No. 2 blast furnace, and will install additional equipment to completely modernize the unit. It is proposed to push the work and have the stack ready for blowing in at an early date.

WITH THE EQUIPMENT MANUFACTURERS

AJAX HEADING MACHINE

The Ajax Manufacturing Company, Cleveland, Ohio, have designed a heavy duty continuous motion heading machine, with the primary purpose of producing machines of ruggedness and durability.

The heads of rivets, carriage bolts and track bolts are formed without flash and do not require trimming. In filling out the corners of square and hex-headed machine bolts, however, a washer shaped flash is thrown out around the bottom of the head, which is afterwards trimmed off cold in a vertical trimming press.

These machines will produce rivets or bolts up to and including the size of their rating from stock at the usual forging temperatures of from 1500 deg. to 1800 deg. F. When operating on stock below the scaling temperatures, commonly known as "semi-hot," the machine is capable of heading work up to three-fourths of its normal rated capacity.

The general arrangement has been improved by transferring the die slide operating mechanism from the left to the right hand side, making it possible for the operator to feed the stock, watch the quality of bolts or rivets as they come through the discharge port, which is on the left, and adjust the stock gauge, all from one position. This arrangement leaves the left hand side of the machine clear, materially expediting the setting of dies and tools. By thus facilitating the operation of the machine and the supervision of production, outputs are increased and the quality of the products improved.

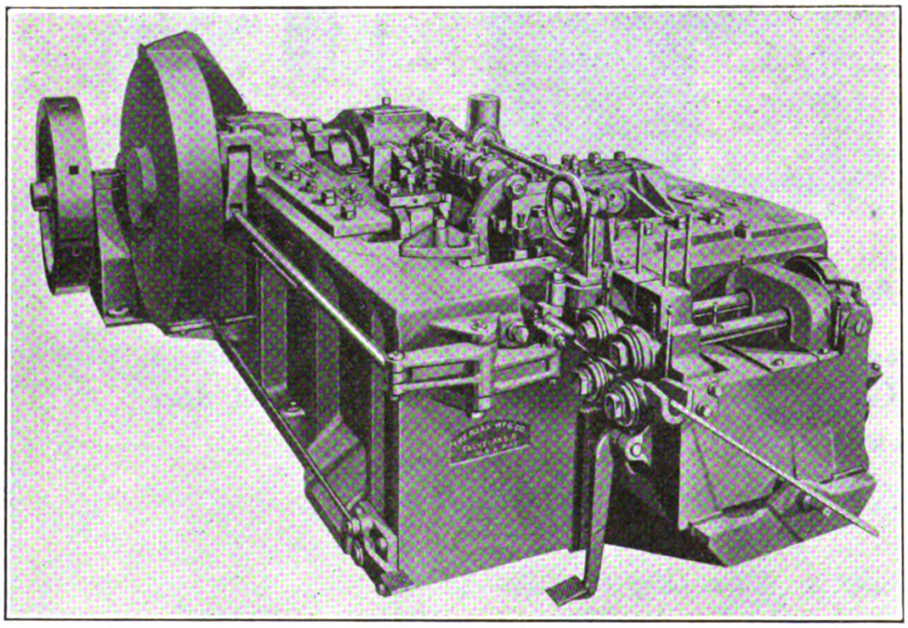

FIG. 1—Ajax continuous heading machine.

The headerslide, of increased length, is maintained in perfect alignment by the "V-type" ways, roll lubricated, in which it operates. The dieslide is top-suspended so that its bearings are not subjected to an accumulation of scale, and its front side liner is adjustable to take up wear so as to assure square shearing of the stock.

With the hand feed machine, rods heated to four or five feet in length are fed into the machine against the stock gauge by the operator by hand, the machine shearing off a blank, heading and ejecting at the rate of from 14,000 to 18,000 counts per 10 hours.

With the automatic roll feed, mill length rods are heated in a long furnace set about three feet from the front of the machine. The operator need only start the rod into the rolls, which feed it into the machine, so that a piece is produced on each revolution. Outputs vary from 30,000 to 50,000 counts per 10 hours, depending on the length and size of rivets produced.

All sizes of machines can be furnished either belt driven through countershaft or direct gear motor driven through safety friction clutch coupling.

The automatic roll feed mechanism is operated from an adjustable crank pin at the end of the crankshaft. The eccentricity of this pin is changed by means of an adjusting screw so that the rolls feed the correct amount of stock to produce any given length bolt or rivet. The rachet arm is fitted with two dogs, staggered to give refinement of feed.

The feed rolls which carry the heated bar stock consist of rings with the circumference grooved to suit the various sizes of stock. They are mounted in holders on the roll shafts so as to be easily changed for different sizes of stock and adjusted laterally for different shear center distances. The roll pressure is controlled by removable weights mounted on the bearings of the upper roll shafts which are movable vertically.

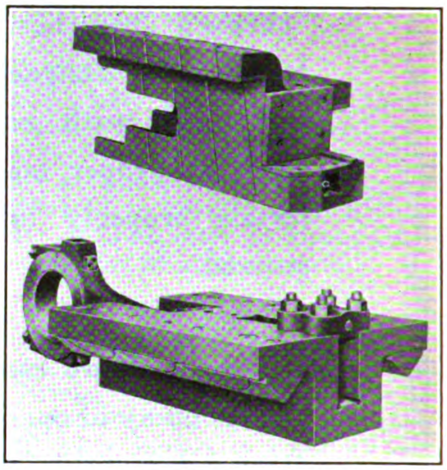

FIG. 2 (Above)—Top-suspended die slide of Ajax heading machine. (Below)—Top-suspended headerslide.

With direct motor drive a safety friction clutch coupling cushions the motor from shocks and protects both the machine and motor from damage should anything prevent a complete revolution of the crankshaft.

The steel bed is of the ribbed type with continuous housings for the crankshaft bearings. It is extremely heavy and its deep sections and liberal flanges make it so rigid between crankshaft and backing plate that it is not necessary to pack up excessively behind the heading tool to bring rivet or bolt heads down to the proper thickness. This eliminates the pounding of the head tool on the dies on idle strokes and increases the life of both accordingly.

The crankshaft is of special analysis steel forging of the single throw, two main bearing type with cylindrical cheeks, and large journal and eccentric pin diameters. All toggle pins are large and of alloy steel.

The headerslide, Fig. 2, is top-suspended from "V-type" bearings.

FEB 7 1925

The Blast Furnace and Steel Plant

Member of the Audit Bureau of Circulations

PITTSBURGH, PA., FEBRUARY, 1925

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